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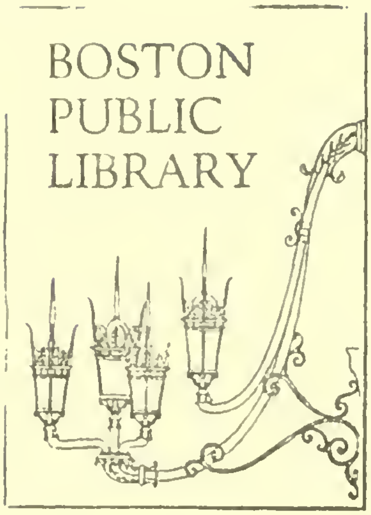

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NOTICE OF PROJECT CHANGE
ON-ISLAND WATER TRANSPORTATION FACILITIES

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July 31, 1986

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CHAIRMAN

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NOTICE OF PROJECT CHANGE

To: All Interested Parties
From: Mass. Water Resources Authority
Re: EOEA 5939, On-Island Water Transportation Facilities
Date: July 31, 1986

On May 15, 1986, the Secretary of the Executive Office of Environmental Affairs issued a final record of decision relative to the On-Island Water Transportation Facilities. That decision states that no harbor filling or dredging be required at Deer Island and Nut Island and that a small number of piles be driven by impact hammers. Pursuant to MEPA Regulation 10.16 the Massachusetts Water Resources Authority is distributing this Notice Of Project Change to acknowledge changes in the project design.

- The changes include the exclusive use of impact hammers for driving piles as opposed to vibratory hammers. This change is dictated by subsurface conditions found in the project sampling program. The use of impact hammers will change the noise impacts of the project. To mitigate the noise impacts shrouds will enclose the hammers and diesel exhausts will be muffled.

- A design option at Deer Island is being studied which calls for bulkhead construction of a wharf to handle bulk cargo. This option would require filling and dredging not previously considered at Deer Island. This option is being investigated for its economic benefits and because it would reduce the amount of pile driving required at Deer Island. A plan of this new option is included with the notice. This option would require the dredging of approximately 120,000 cubic yards of marine sediment.

- Two short pier options at Nut Island (one on the East side and one on the Northeast side) remain viable alternatives at this point in the project. Either option would require dredging of approximately 70,000 cubic yards of material. Sediment and benthic sampling for both options has been done. Data from the East side has been reviewed by COE, EPA, DWPC and C2M. Data from the Northeast location should be available shortly.

Written comments on this notice should be addressed to the Secretary of Environmental Affairs at 100 Cambridge Street, Boston, Massachusetts 02202. It is requested that comments be received by the SEcretary's Office by August 20, 1986. A brief information meeting relative to this notice is scheduled for 10:00 A.M., August 15, 1986 in the EOEA Conference Room on the 20th Floor at 100 Cambridge Street. For information on this meeting please contact Mr. David Shepardson, MEPA Unit, at 727-5830.

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NOTICE OF PROJECT CHANGE
ON-ISLAND WATER TRANSPORTATION FACILITIES

On February 28,1986 the MWRA filed an Environmental Notification Form (ENF) for its permanent On-Island Water Transportation Facilities at Deer Island and Nut Island. On May 15, 1986 MEPA issued its Final Record of Decision and waived the categorical inclusion status of the project. MEPA's letter was based on several assumptions which are described therein.

As the project study has advanced, the MWRA and its consultants have met with the residents of Winthrop and Quincy and have continued with its engineering investigations and evaluations of several pier options at both Deer Island and Nut Island.

Three changes have occurred during the course of the study:

1. A dredging option is now being evaluated at Deer Island.
2. Pier options for the northeast side of Nut Island are now being reviewed in response to concerns by Quincy citizens.
3. The soil strata and geologic makeup at the proposed pier locations have been determined to preclude the use of vibratory hammers for pile driving.

Attached is a copy of MEPA's letter dated July 22, 1986 to the MWRA in reference to the MWRA's informal discussion with MEPA as to the best method of proceeding at this time.

The following information is enclosed:

1. A copy of MEPA's letter dated July 22, 1986 to MWRA.
2. A copy of the draft outline for both the Facilities Plan and an EIR for the On-Island Water Transportation project and a general description of the scope of each section of the EIR.
3. A description of geotechnical considerations at the Deer Island and Nut Island pier sites.
4. A discussion of pile driving noise assessments and alternate methods of mitigating noise from impact hammers.
5. A detailed description of the sediment sampling program completed at both Deer Island and Nut Island.
6. The draft report describing the results of the "Ecological Evaluation of Proposed Oceanic Discharge of Dredged Material".
7. A detailed description of the additional sampling program recently initiated for the area around the new northeast pier options at Nut Island. Results of this program will be included in the EIR.
8. Plans showing the locations of the final pier locations still under study at Deer Island and Nut Island.

The Commonwealth of Massachusetts
Executive Office of Environmental Affairs
100 Cambridge Street
Boston, Massachusetts 02202

MICHAEL S. DUKAKIS
GOVERNOR

JAMES S. HOYTE
SECRETARY

July 22, 1986

Daniel K. O'Brien, P.E.
Director of Wastewater Engineering
Massachusetts Water Resources Authority
20 Somerset Street, Fourth Floor
Boston, Ma. 02108

Re: EOEA 5939, On-Island Water Transportation Facilities

Dear Mr. O'Brien,

The MWRA has notified this office of changes in the above project. The changes were discussed at a meeting with David Shepardson of the MEPA staff, and review personnel of other agencies, on July 8, 1986. Pursuant to 301 CMR 10.16, it is the determination of the Secretary that rescoping and preparation of an EIR are warranted.

Background

During January, 1986, we reviewed the MWRA's ENF for EOEA 5833, Interim Ocean Sludge Disposal Project: Sludge Transfer, Storage and Loading Facilities. On February 10, 1986, a Scope was issued, which went to considerable lengths to guide the Authority in narrowing down a range of alternatives to a preferred alternative that minimized impacts and regulatory constraints.

On February 28, the MWRA filed the ENF for 5939, the permanent On-island Water Transportation Facilities. In discussions preceding that filing, MEPA staff and representatives of the MWRA ascertained that the project was categorically included as a new marine terminal (301 CMR 10.32(5)(a)(20), and that therefore an EIR would be required by regulation, unless the Secretary were able to make a finding that the impacts of the project would be insignificant.

As head of the MEPA Unit, I have made clear to the MWRA my desire to use the EIR process, where appropriate, to review and evaluate the MWRA's manifold forthcoming activities, but, conversely, not to require EIRs where no real value would be gained by such a document. In this instance, I encouraged the MWRA to see whether by careful project planning, the need for an EIR and the accompanying 6-9 month delay could be avoided.

the MWRA in connection with the three impacts in question: the need for pile-driving, and noise impacts thereof; footprints, sampling results and test data for dredging proposed; and all information on amount and location of filling/bulkheading proposed.

Accompanying the Notice should be a Proposed Scope for the EIR, prepared by the consultants who have been working on the project. This should not be limited to a simple outline (such as the form a consultant's scope of work often takes), but should include brief narrative of the material to be presented in the Draft EIR, and specify factors such as core depth, sampling locations, and analytical methods being used.

If the backup material is voluminous, circulation may be restricted to the permitting agencies involved, but the Notice, plans of alternatives and Proposed Scope should be sent to all recipients of the original ENF, and to those persons who attended the March consultation session.

The Notice should also be accompanied by a copy of this letter, and the text of the Notice should include a request that written comments on the Notice be provided to the Secretary by reviewing agencies and interested members of the public within twenty days of receipt of the Notice. Within ten days thereafter, we will issue a formal Scope for the EIR.

It should be noted that the obtaining of a Scope and of agency comments will be an important protection to the MWRA, to ensure that the Draft EIR will meet agency requirements. It should not, however, delay the expeditious preparation of the Draft EIR, the preparatory studies for which are already no doubt underway and the requirements for which are rather easily predictable.

If you have any questions, please call Dave Shepardson at 727-5830.

Sincerely,

Samuel G. Mygatt

Samuel G. Mygatt
Assistant Secretary,
Environmental Impact Review

cc: M. Hotch, Esq.

DRAFT OUTLINE

ON-ISLAND WATER TRANSPORTATION FACILITIES

ENVIRONMENTAL IMPACT REPORT (EIR)

DRAFT EIR TITLE PAGE

PROJECT ABSTRACT

EXECUTIVE SUMMARY

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1.0 COPY OF ENVIRONMENTAL NOTIFICATION FORM

2.0 SUMMARY

- 2.1 Identification of Project
  - 2.1.1 Project Name
  - 2.1.2 Proponent Name
  - 2.1.3 Federal and State identification numbers
  - 2.1.4 Identify EIR as draft or final
- 2.2 Brief Description of Project
  - 2.2.1 Description including identification of affected communities (County, Municipalities)
  - 2.2.2 Summary of major benefits, costs, and environmental impacts of project and alternatives

3.0 DESCRIPTION OF PROJECT

- 3.1 Type of Objectives of Project, including Specific Discussion of Benefits
- 3.2 Project Characteristics (size, location w/map...)
  - 3.2.1 General Pier Requirements
  - 3.2.2 Deer Island Pier Facilities
  - 3.2.3 Nut Island Facilities
- 3.3 Timetable of Pier Construction
- 3.4 Methods of Construction

4.0 PROJECT ALTERNATIVES

- 4.1 Deer Island
  - 4.1.1 No Action
  - 4.1.2 Alternative Sites for Water Transportation Facilities
  - 4.1.3 Water Transportation Facility Requirements

      - Traffic (total and peak hour traffic)
      - Visual impacts (including sketches of pier alternatives)
  - 6.1.3 Operations Impacts
    - (a) Impacts to Marine Environment
      - water quality
      - marine life
      - recreation
      - navigation
    - (b) Impacts to Deer Island Terrestrial Environment
      - treatment plant operation (Cl_2)
      - recreation
    - (c) Community Impacts
      - Noise
      - Traffic
      - Visual Impacts
- 6.2 Nut Island
  (same as for Deer Island above)

7.0 MEASURES TO MINIMIZE ENVIRONMENTAL DAMAGE

- 7.1 Pier / Dock Location
- 7.2 Pier / Dock Design
- 7.3 Method and Season of Dredging
- 7.4 Pile Driving Equipment
- 7.5 Visual Aspects of Pier Design

8.0 PERMIT REQUIREMENTS

- 8.1 Public Trust for Tidewater
- 8.2 Dredge and Fill
- 8.3 Wetlands Protection Act
- 8.4 U.S. Army Corps of Engineers
  - 8.4.1 Section 10 Permit
  - 8.4.2 404 Permit
  - 8.4.3 Ocean Dumping (Section 103)
- 8.5 Water Quality Certificate
- 8.6 Coastal Zone Management Consistency Certification

9.0 COMMENTS OF AGENCY AND PUBLIC REVIEWERS

- 9.1 List of Agencies to which EIR will be submitted
- 9.2 Comments and Responses (Final EIR only)

APPENDICES

APPENDIX A: SUMMARY OF EIR SCOPING

APPENDIX B: REPORT OF SEDIMENT SAMPLING AND ANALYSIS

APPENDIX C: LIST OF PREPARERS

CONTENTS OF ENVIRONMENTAL IMPACT REPORT
FOR
ON-ISLAND WATER TRANSPORTATION FACILITIES

The Draft Environmental Impact Report (EIR) now being prepared for Water Transportation Facilities at Deer Island and Nut Island addresses each of the items included in the Commonwealth of Massachusetts regulations on the preparation of EIR's. The report will follow the organization of those regulations (see attached outline). The following paragraphs summarize the contents of each section of the EIR. The attachments which follow this summary provide additional details on the major areas of data collection and analysis (such as sediment sampling and noise analysis).

Introductory Information

The first pages of the Draft EIR will include the title page, a one page project abstract, an executive summary of about five to ten pages, a table of contents, a list of figures, and a list of tables.

Section 1: Copy of ENF

The first section of the EIR will be a copy of the ENF for this project and any pertinent information on the disposition of the EIR. This section will also reference Appendix A of the EIR which is a summary of project scoping.

Section 2: Summary

This Section will begin with project identification information such as project name, proponent name, and project identification numbers used by participating agencies. This will be followed by a brief description of the project highlighting affected communities, and the benefits, costs, and environmental impacts of the project and its

alternatives. The major benefits are related to the avoidance of automobile and truck traffic in Winthrop and Quincy neighborhoods. The costs of the proposed facilities are on the order of $10 Million at Deer Island and $4-5 Million at Nut Island. The most significant impacts of the project are noise of pile driving, marine impacts of dredging, construction traffic, and pier aesthetics. Analysis of these and other impacts has already lead to the development of design changes and other mitigating actions which reduce adverse impacts to acceptable levels.

Section 3: Description of Project

Section 3 will provide details on the proposed project including a specific discussion of its benefits and the pier characteristics. The rationale for pier size, type and configuration will be detailed under the subsection on pier requirements. For both Deer and Nut Islands tables will summarize major pier characteristics such as number of berths (for each type of vessel), deck area, and cost. Figures depicting each of the final alternatives will include scale plans and cross sections on 11"x17" report fold outs. This section will also include a timetable for project development and a discussion of pier construction methods.

Section 4: Project Alternatives

Section 4 describes the full range of alternatives considered during the development of recommended alternatives. These alternatives include all possible pier sites, 11 alternative designs for water transportation facilities at Deer Island and 8 alternative designs at Nut Island. The section will describe in detail the development of criteria used to evaluate the alternatives. These criteria include facility requirements (such as navigation, berthing area and draft requirements) marine environmental impacts, impacts to adjoining communities (such as noise, traffic and visual impacts), costs, and construction considerations. The section will then show how these

criteria lead to the screening of alternatives and the selection of the recommended plan.

Section 5: Description of the Affected Environment

This section describes the affected environment at Deer Island and Nut Island in separate subsections. For each island site and its adjoining community the EIR describes the affected environment by subject, beginning with the natural environment (physiography, water resources, sediment characteristics...) and ending with the human environment (recreation, noise, traffic...). A complete list of subjects included in this Section appears in the attached outline. The subjects correspond to those in MEPA's regulations on EIR preparation. Maps, photographs, illustrations and tables will be used to quantify and delineate the resources included under each subject.

The level of detail included in these discussions will be commensurate with the value of the resource and/or the significance of potential impacts related to the resource. For example, the discussion of wetlands is brief since vegetated wetlands are virtually non-existent at both sites. Conversely, much detail is provided on sediment quality, biological resources, noise, and visual quality. Programs for Sediment/Biological Sampling and Noise Monitoring data attached to this summary show the detail of the baseline analysis for these subjects.

Section 6: Environmental Impacts of Proposed Project and its Alternatives

The section contains two subsections; one for Deer Island and one for Nut Island. Each of these subsections begins with a brief summary describing the major impacts of the final alternatives and the influence of those impacts on the development of mitigating actions and the selection of the recommended alternatives. These summaries will each include a table summarizing the major characteristics and impacts of each of the alternative facilities.

The remainder of the Section is broken into separate discussions of construction impacts and pier operations impacts. Construction impacts includes impacts to the marine environment (see attached sediment sampling and analysis program), impacts to the island's terrestrial environment, and community impacts. The community impacts discussion will highlight noise (see attached noise monitoring and analysis program), total and peak hour traffic, and visual impacts (including sketches of the final pier alternatives). The Operations Impacts discussion follows the same subject organization as the discussion of construction impacts. Recreation will also be highlighted in this discussion.

Section 7: Measures to Minimize Environmental Damage

This Section focuses on the actions to be taken to mitigate adverse impacts of pier construction and operations. These actions will be incorporated into the recommended plan. The mitigating actions discussed in this section are: pier location, design, method and season of dredging, pile driving equipment and visual aspects of pier design.

Section 8: Permit Requirements

This section describes the permits which must be obtained prior to pier construction. The legislative source, authorizing agency's regulations, permit requirements and process are all described (see attached outline for list of permits).

Section 9: Comments of Agency and Public Reviewers

This section in the Draft EIR will include a list of agencies to which the EIR will be submitted, and any agency / public comment received during Draft EIR preparation (an EIR Scoping Summary appears as a separate section, Appendix A). In the Final EIR this section will also include the comments received on the Draft EIR and the responses to the comments.

Appendices

Appendices to the Draft EIR will include a Summary of EIR Scoping, a report on the sediment sampling and analysis program, and a list of preparers.

4.0 CONSTRUCTION WORKFORCE AND PLANT PERSONNEL TRAFFIC

- 4.1 DEER ISLAND CONSTRUCTION WORKERS
  - 4.1.1 Deer Island Pier Construction
  - 4.1.2 Deer Island Site Preparation
  - 4.1.3 Deer Island Primary Plant Construction
  - 4.1.4 Deer Island Secondary Plant Construction
  - 4.1.5 Outfalls and Underharbor Tunnel
- 4.2 NUT ISLAND CONSTRUCTION
- 4.3 DEER ISLAND AND NUT ISLAND PLANT OPERATION PERSONNEL

5.0 DEER ISLAND BULK HANDLING PIER

- 5.1 TYPES OF MATERIALS TO BE HANDLED
- 5.2 ADVANTAGES AND DISADVANTAGES OF ALTERNATE MODES OF TRANSPORT
- 5.3 DESIGN CRITERIA
  - 5.3.1 Wind, Waves, Currents, Tides and Ice
  - 5.3.2 Construction Loadings
  - 5.3.3 Channel Criteria, Marine Traffic and Anchorage
  - 5.3.4 Pier Utilities
  - 5.3.5 Environmental Protection
- 5.4 ALTERNATE TYPES OF PIER CONSTRUCTION
- 5.5 CONCRETE BATCH PLANT
- 5.6 MATERIALS HANDLING SYSTEMS
- 5.7 SPARE / EMERGENCY BARGE SPACE

6.0 ROLL-ON / ROLL-OFF PIER

- 6.1 DESCRIPTION OF TYPES OF MATERIALS TO BE HANDLED
- 6.2 CRITICAL DESIGN CRITERIA
  - 6.2.1 Roll-on / Roll-off Vessels
  - 6.2.2 Marine Traffic and Channel Criteria
- 6.3 ALTERNATE TYPES OF DOCK CONSTRUCTION

7.0 PERSONNEL PIER

- 7.1 DESIGN CRITERIA
- 7.2 ALTERNATE TYPES OF PIER CONSTRUCTION
- 7.3 ALTERNATE DOCK LOCATION CONSIDERATIONS
  - 7.3.1 Construction Workers
  - 7.3.2 Plant Operation Personnel
  - 7.3.3 Island Facilities
- 7.4 SCHEDULING CONSIDERATIONS

8.0 GEOTECHNICAL CONSIDERATIONS

- 8.1 DEER ISLAND GENERAL GEOLOGY AND SUBSURFACE CONDITIONS
- 8.2 NUT ISLAND GENERAL GEOLOGY AND SUBSURFACE CONDITIONS
- 8.3 GOETECHNICAL CONDITIONS OF PROPOSED PIER LOCATIONS

9.0 ALTERNATE DOCK DESIGN - DEER ISLAND

- 9.1 DESCRIPTION OF ALTERNATES
  - 9.1.1 Three Pier Option
  - 9.1.2 One Combined Pier and One Floating Batch Plant Pier (One Ro-Ro)
  - 9.1.3 One Combined Pier and One Floating Batch Plant Pier (Two Ro-Ro)
  - 9.1.4 One Bulk Pier and One Personnel/Single Ro-Ro Pier
  - 9.1.5 One Bulk Pier and One Personnel/Dual Ro-Ro Pier
  - 9.1.6 Single Pier - One Roll-on / Roll-off
  - 9.1.7 Single Pier - Dual Roll-on / Roll-off
  - 9.1.8 One Combined Pier and Bulk Head W/Dredging
  - 9.1.9 Large Barge Roll-on / Roll-off Barge Pier and Floating Batch Plant
  - 9.1.10 Large Barge Roll-on / Roll-off Pier and One Bulk Pier
  - 9.1.11 Single Large Barge Pier

10.0 ALTERNATE DOCK DESIGNS - NUT ISLAND

- 10.1 DESCRIPTION OF ALTERNATES
  - 10.1.1 Extended Pier - East Side
  - 10.1.2 Short Pier - East Side (Dredging)
  - 10.1.3 Barge Groundout (No Dredging)
  - 10.1.4 Extended Pier - Northwest Side
  - 10.1.5 Short Pier - Northwest Side
  - 10.1.6 Extended Pier - North Side
  - 10.1.7 Short Pier - North Side
  - 10.1.8 No Pier Option

11.0 COMPARISON OF ALTERNATES - DEER ISLAND

- 11.1 GENERAL
  - 11.1.1 Option 9.1
  - 11.1.2 Option 9.6
  - 11.1.3 Option 9.7
  - 11.1.4 Options 9.9, 9.10 and 9.11
  - 11.1.5 Options 9.2, 9.3, 9.4, 9.5 and 9.8
- 11.2 PIER CONSTRUCTION
  - 11.2.1 Cost Comparisons
  - 11.2.2 Pile Driving
  - 11.2.3 Construction Time
  - 11.2.4 Dredging
- 11.3 PIER OPERATION DURING PLANT CONSTRUCTION
  - 11.3.1 Pier Flexibility
  - 11.3.2 Compatibility w/Treatment Plant Operations
  - 11.3.3 Relative Land Use / Space Considerations
  - 11.3.4 Flexibility During Inclement Weather
  - 11.3.5 Materials Handling Systems
  - 11.3.6 Pier / On-Shore Traffic
- 11.4 LONG TERM RECREATIONAL / AESTHETIC CONSIDERATIONS
  - 11.4.1 Ease of Dismantling
  - 11.4.2 Fishing and Boating Access

        11.4.3 Visual Impacts
    11.5 RECOMMENDED OPTION

12.0 COMPARISON OF ALTERNATES - NUT ISLAND

    12.1 GENERAL

    12.2 PIER CONSTRUCTION
        12.2.1 Cost Comparisons
        12.2.2 Pile Driving
        12.2.3 Construction Time
        12.2.4 Dredging
    12.3 PIER OPERATION DURING CONSTRUCTION
        12.3.1 Pier Flexibility
        12.3.2 Compatibility w/Treatment Plant Operations
        12.3.3 Relative Land Use / Space Considerations
        12.3.4 Flexibility During Inclement Weather
        12.3.5 Materials Handling Systems
        12.3.6 Pier / On-Shore Traffic
    12.4 LONG TERM RECREATIONAL / AESTHETIC CONSIDERATIONS
        12.4.1 Ease of Dismantling
        12.4.2 Fishing and Boating Access
        12.4.3 Visual Impacts
    12.5 RECOMMENDED OPTION

13.0 ADMINISTRATION AND LEGAL CONSIDERATIONS

    13.1 GENERAL

    13.2 OWNERSHIP / OPERATION RESPONSIBILITY

    13.3 NAVIGATION CONTROL, FENDERING

    13.4 PIER CONSTRUCTION SCHEDULE

14.0 SUMMARY AND CONCLUSIONS

APPENDIX A - ALTERNATES TO TRUCKING CHLORINE

APPENDIX B - PERMITS

8.0 GEOTECHNICAL CONSIDERATIONS

Deer Island and Nut Island are both located within the geologic feature known as the Boston Basin. This basin is a down-faulted area which extends southward to parts of Quincy, Weymouth and Hingham, westerly to Route 128 in Newton, northerly to Lynn and easterly out into Massachusetts Bay. The rocks making up the Boston Bay Group of the basin are principally sedimentary and include conglomerate, sandstone, volcanic sediments and flows, siltstone and argillite. The various rock types grade into and are interbedded with each other.

Overlying the bedrock are soil strata of glacial till and glacial outwash, organic soils, sands and gravels of an erosional nature and fills placed for engineering purposes. The most prominent geologic features of both Deer Island and Nut Island are landforms known as drumlins. Drumlins are rounded mounds of glacial till which lie directly on the bedrock surface. They are numerous in the Boston Area with Beacon Hill, Breeds Hill, Parker Hill, and Savin Hill at Uphams corner all excellent examples.

The rounded streamlined contours of drumlins result from the shaping action of glacial ice flow around and over a mass of till. As glaciers receded, the meltwaters carrying suspended sand, silt and clay particles slowed down upon entering the ocean and released their sediment load. The particles settled and formed a stratum of outwash over the drumlins which partially or completely buried them. What remains of the outwash today is the eroded surface with the more resistant drumlins protruding up through the stratum. Organic soils subsequently developed on the surface of the outwash during periods of lower relative sea level. These organic deposits are the partially decomposed remains of vegetation mixed with sand, silt and clay. Organic deposits overlying the outwash of marine clay are found at both Deer and Nut Island. At various locations erosional deposits of sand and gravel (beach deposit) overlie the organic soils. These beach and erosional depositions are of very recent geological origin.

The latest physiographic modifications consist of manmade cuts and fills which have altered the shape and profile of the Islands.

8.1 DEER ISLAND GENERAL GEOLOGY AND SUBSURFACE CONDITIONS

The Deer Island peninsula, formerly an island proper, is a formation consisting of two well defined drumlins with sand and gravel beach deposits. It is located near the center of the Boston Basin. The Island has been extensively modified over the years by the construction of correctional facilities, the sewage treatment plant, a causeway fill across Shirley Gut and the Fort Dawes Military Facilities (now mostly ruins). In addition, much of the old shoreline was modified by fills, walls, piers and revetments. The southern part of the peninsula (south of the large drumlin) may have pockets of organic deposits buried beneath fills placed in the first half of the century. Topographic mapping (U.S. Geological Survey) performed in 1886-1887 indicated a large portion of the Island south of the central drumlin to be marshland.

The present configuration of the Deer Island peninsula is that of an elongated somewhat irregular elliptical land mass trending northwest/southeast. The drumloidal hills also trend northwest/southeast and they are surrounded by a shield of erosional deposits of sand and gravel, as well as fill placed over the years. At least one of the major fills modifying the outline of the Island is composed of excavated material from tunnel construction in the 1950's. The Island is now connected at the northwest end to Point Shirley, Winthrop, by fill placed in the former Shirley Gut Channel. Point Shirley is another well contoured drumloidal hill.

The stratification and geotechnical properties of the soils at the proposed pier site have been investigated by Goldberg-Zoino in a Geotechnical Data Report to Havens and Emerson / Parsons Brinkerhoff dated November 29, 1983. This report was prepared for proposed expansion of the Deer Island plant.

Subsurface explorations consisting of 3 borings were taken at the site of the proposed pier facilities. This location is referenced in the Geotechnical Data Report as Wharf Site No. 2 and is included herein as Figure 8.1. Other available data consists of contract drawings for the sewage treatment plant construction with borings dated 1954, and other investigation boring logs obtained over the years. Soil profiles are indicted on Figures 8.2, 8.3, and 8.4 for the Deer Island Pier Site.

The stratification from the bedrock upward is generally as follows:

- Bedrock is presumed to consist of Cambridge argillite although at the specific location of the proposed pier it was not sampled. In borings near the existing treatment plant and at locations east of Deer Island the rock cores consist of argillite. The bedrock northwest of the pier site was encountered at a depth of over 150 feet (Elevation -134) near the historic pumphouse. East of the pier site (and east of the Island), rock was encountered at between Elevation -40 to -60, illustrating considerable relief in the rock surface. The rock was moderately hard where sampled nearby but this could vary considerably from place to place.

- Overlying the bedrock is a layer of glacial till of varying thickness. The glacial till is composed of very dense sand, gravel, silt, clay, cobbles and boulders, and forms much of the Deer Island landform. The till underlies the pier site at a depth which varies from about Elevation -70, several hundred feet off-shore to about -50 at the shoreline. The till slopes upward toward the drumlin and presumably thickens in that direction as well. Standard penetration test blow counts in the till vary widely but average about 50 blows per foot in the upper part of the stratum.

- The glacial outwash of silty marine clay overlies the glacial till. This marine clay is present up to about Elevation -16 on shore and the clay surface slopes downward away from shore. In

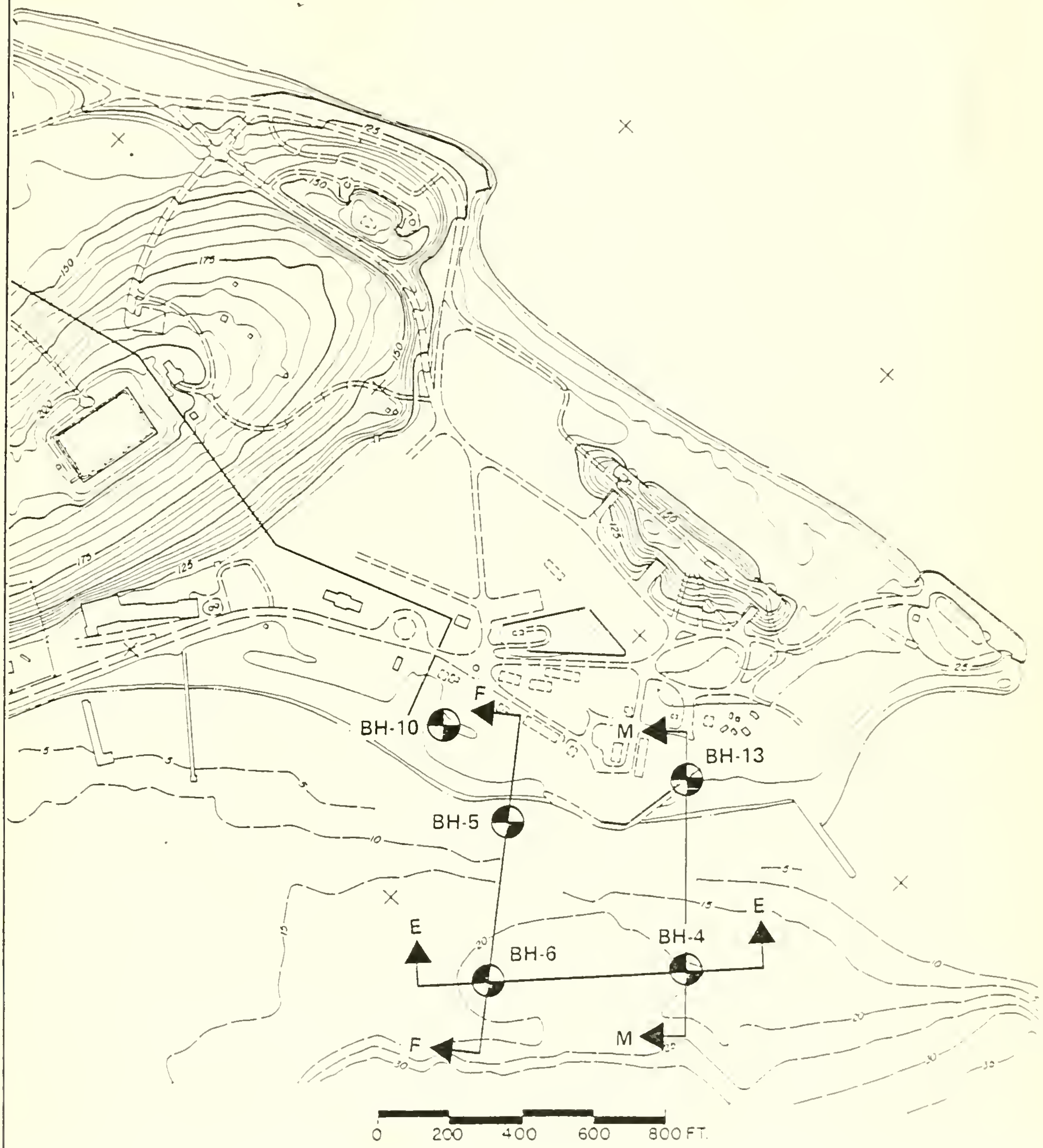
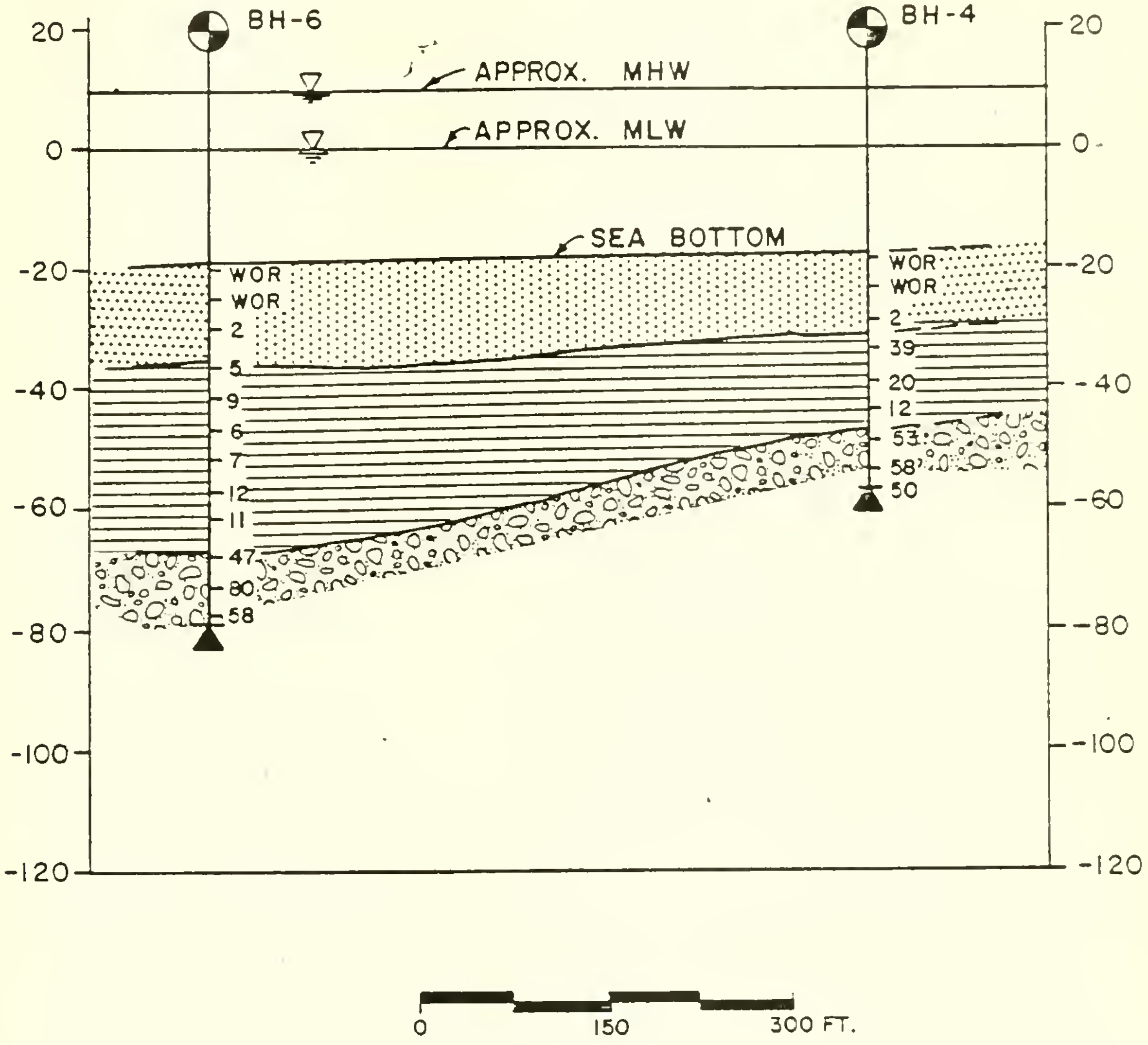


Figure 8.1
DEER ISLAND BORING LOCATION PLAN

On-Island Water Transportation Facilities

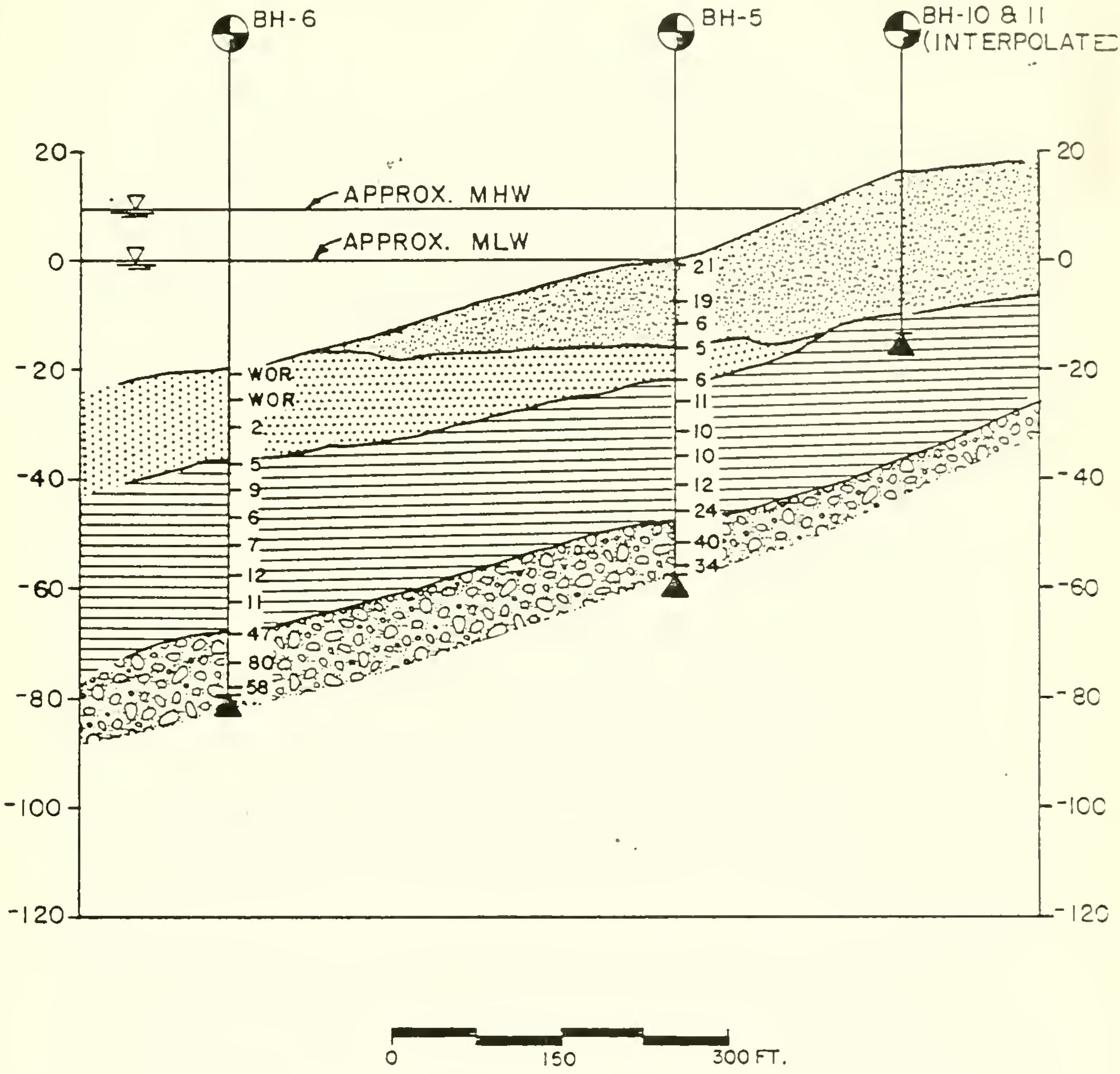


NOTE
DATA FOR PREPARATION OF THESE GENERALIZED SOIL PROFILES IS FROM THE DEER ISLAND TREATMENT PLANT FACILITIES PLAN, GEOTECHNICAL DATA REPORT. PREPARED BY GOLDBERG & ZOINO ASSOC., NOV. 1983

LEGEND
⁙ Organic Silt
☰ Marine Clay
° Glacial Till

Figure 8.2
GENERALIZED SOIL PROFILE
DEER ISLAND

On-Island Water Transportation Facilities



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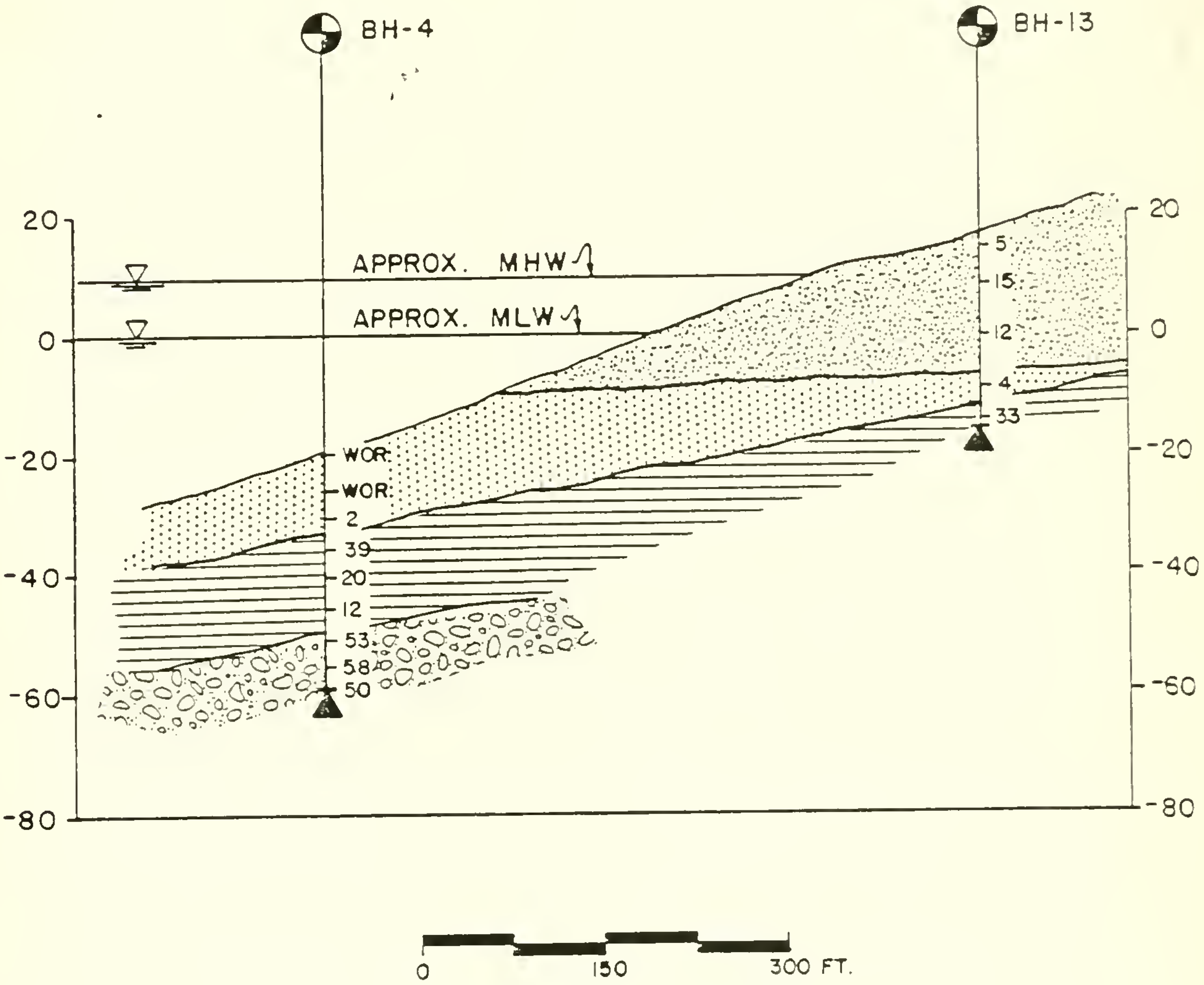
LEGEND

- Sand
- Organic Silt
- Marine Clay
- Glacial Till

Figure 8.3
GENERALIZED SOIL PROFILE
DEER ISLAND

On-Island Water Transportation Facilities



NOTE
DATA FOR PREPARATION OF THESE GENERALIZED SOIL PROFILES IS FROM THE DEER ISLAND TREATMENT PLANT FACILITIES PLAN, GEOTECHNICAL DATA REPORT. PREPARED BY GOLDBERG & ZOINO ASSOC., NOV 1983

LEGEND
- ░ Sand
- ▒ Organic Silt
- ☰ Marine Clay
- ○ Glacial Till

Figure 8.4
GENERALIZED SOIL PROFILE
DEER ISLAND

On-Island Water Transportation Facilities

general, the clay stratum thickens out into Boston Harbor. At 400 feet off shore near Boring BH-6 the thickness is about 30 feet. The marine clay is stiff in consistency with standard penetration test values in the range of 5 to 20 blows per foot, averaging about 11 blows per foot.

- Organic silt (muck) mixed with fine sand and shells overlies the stratum of marine clay. This deposit formed when the relative sea level was lower than today at a time when Deer Island was surrounded by tidal marshland. This deposit is very soft in consistency and possesses little engineering strength.

  The organic silt stratum is not present at all locations in the pier area. Borings taken along the outfall line toward Deer Island Light (at the time of original construction) did not encounter organic silt. It is likely that this material did not develop extensively or was washed away in the more exposed locations.

- Beach deposits and possible fill overlie the organic silt to some extent. The beach deposits of fine sand and deposits of sand and gravel are present near shore but appear to feather out and are absent several hundred feet out. At this point the organic silt forms the uppermost stratum.

  Beach deposits and fill are on the order of 15 feet thick over the organic silt at the shore and are thicker toward the inland areas.

8.2 NUT ISLAND GENERAL GEOLOGY AND SUBSURFACE CONDITIONS

Nut Island in former years was a small drumloidal hill isolated from the mainland. It is now connected to the mainland by an extensive fill upon which part of the Nut Island Sewage Treatment Plant was constructed. The present physiography of Nut Island is that of a rectangular peninsula projecting northwesterly into Quincy Bay. The

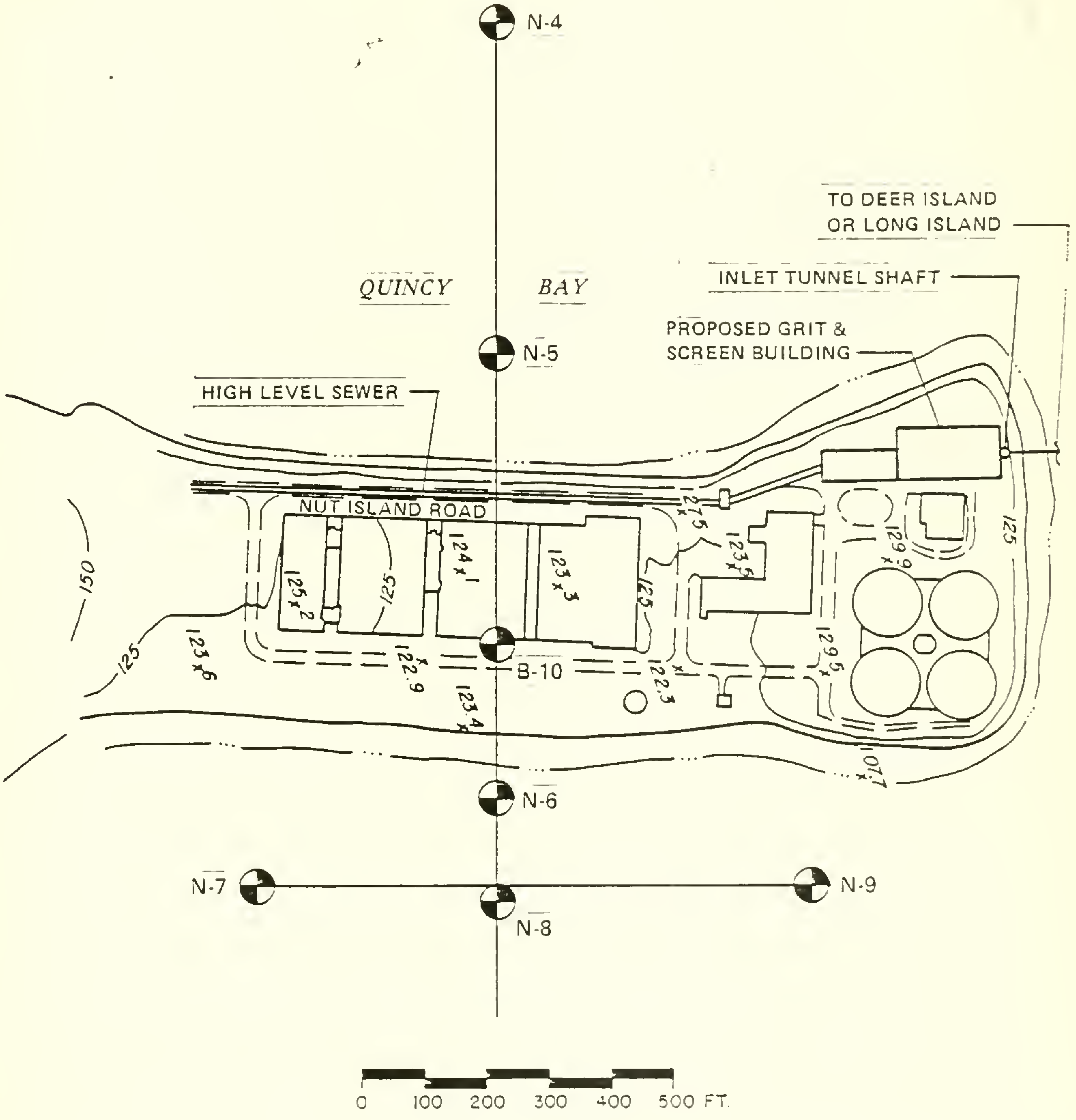
peninsula extends northwesterly from a second and much larger drumlin, Quincy Great Hill, located at Hough's Neck, Quincy.

Properties of the soils and rock at the Nut Island Peninsula have been described in a draft geotechnical report which was prepared by Metcalf and Eddy in 1983. The report includes borings (July 1981, November 1967), laboratory testing, profiles, and preliminary recommendations for Nut Island treatment plant site expansion. This report was provided to CE Maguire for review during this current phase of work and most of the geotechnical considerations discussed herein derive from the Metcalf and Eddy (M&E) data.

Subsurface exploration logs supplied in the M&E data located on Figure 8.5 provide some information on the bedrock and soils underlying the proposed pier facilities along the northeast margin of the peninsula. The stratification shown on Figures 8.6 and 8.7 from the bedrock upward is generally as follows:

- The bedrock which underlies the site consists of Cambridge argillite. At the Nut Island Peninsula the argillite is generally dark gray and moderately hard. Rock quality designation values run about 50% but wide variation has been observed. The surface of the rock is at about Elevation -50 to -60 along the northeast margin and apparently deepens toward the north and east. The bedding planes in the argillite are steeply inclined, indicating considerable folding of the stratum in the geologic past.

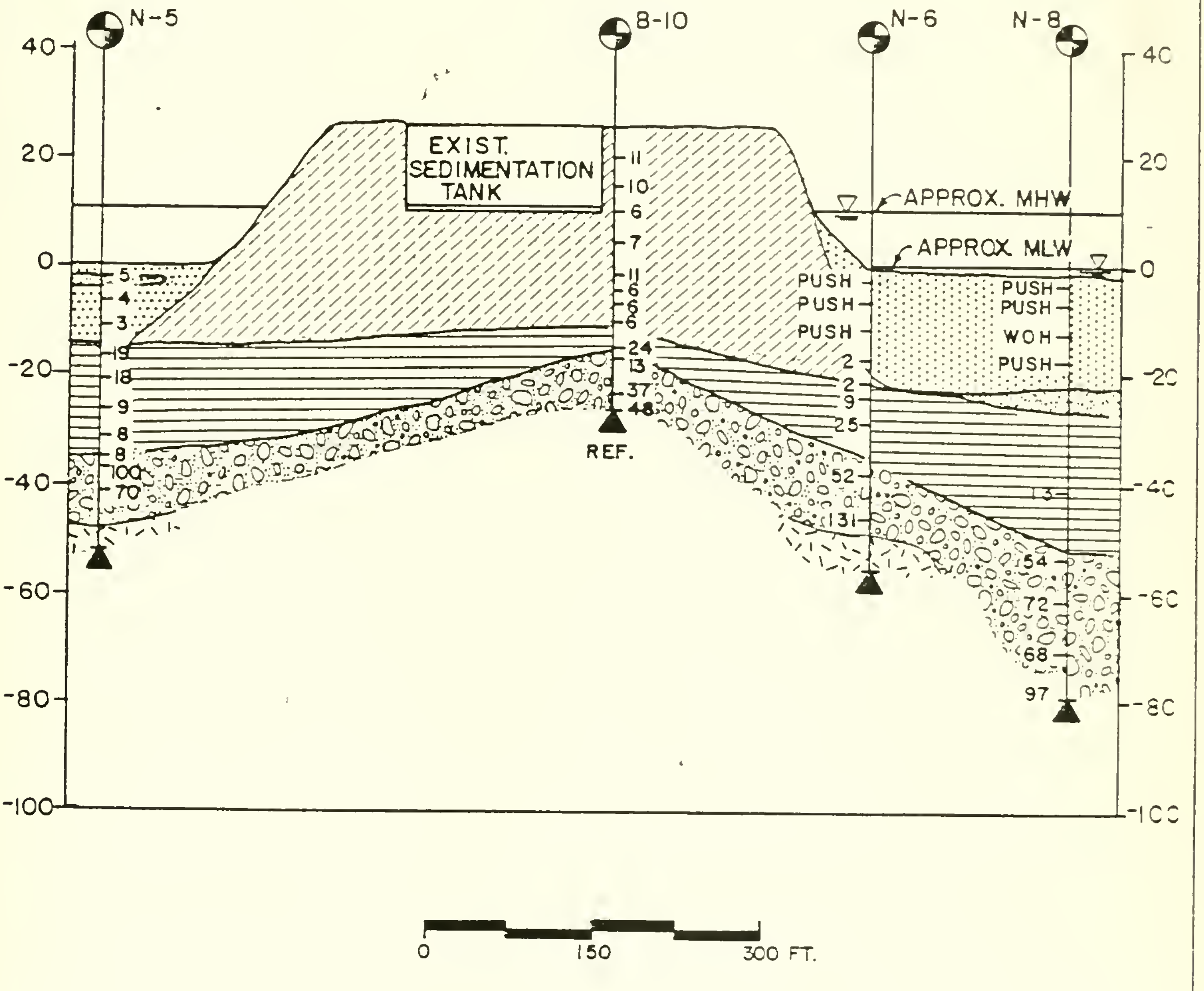
- Glacial till overlies the bedrock. The till is composed of a hetrogeneous mixture of clay, sand and gravel and silt, with scattered cobbles and boulders occasionally reported. The till is very dense as indicated by the standard penetration test values. Standard penetration blow counts are generally well in excess of 50 blows per foot.



Note:
Shaded Area Denotes New Facilities.
Unshaded Facilities Will Not Be Used.

Figure 8.5
NUT ISLAND BORING LOCATION PLAN

On- Island Water Transportation Facilities



NOTE

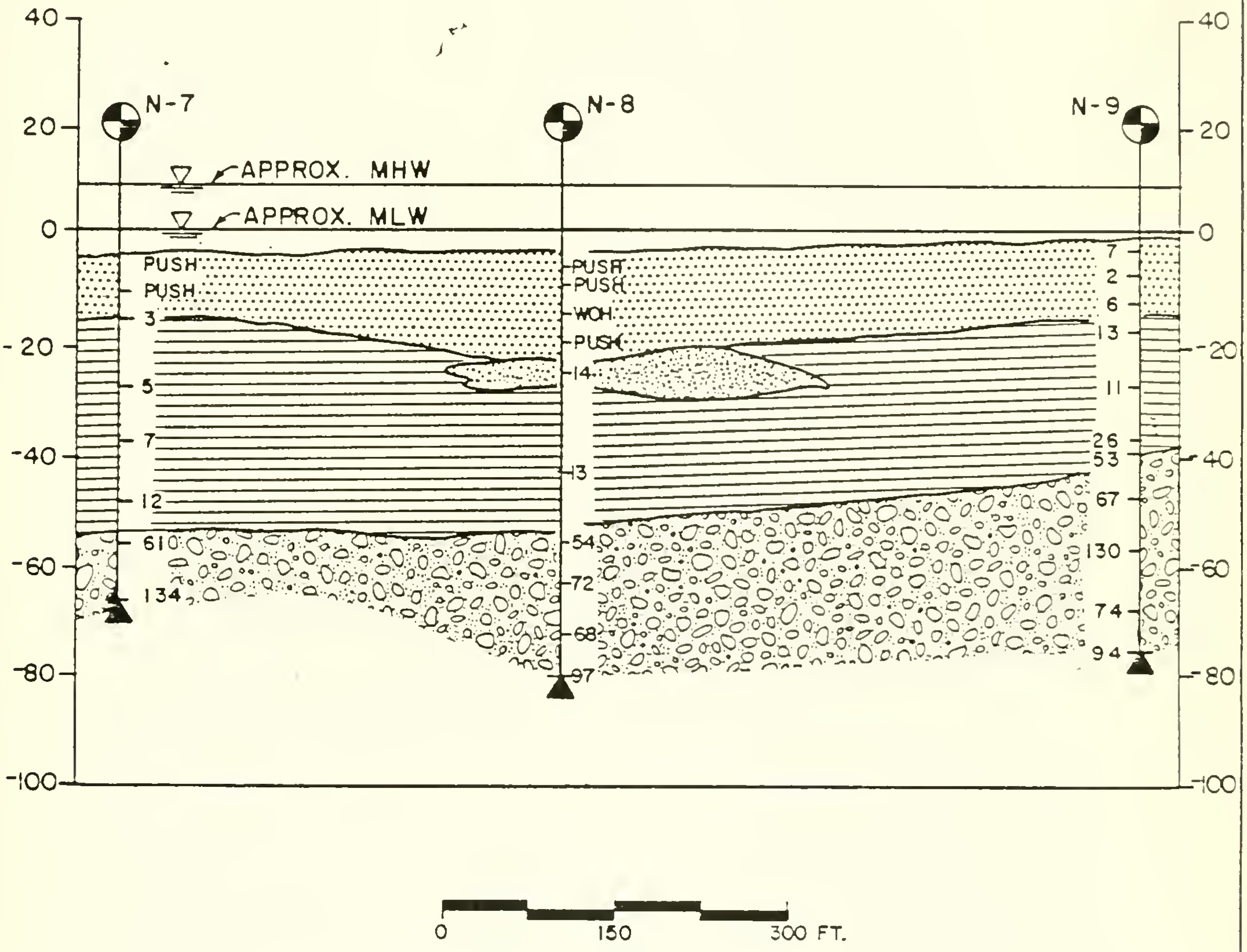
DATA FOR PREPARATION OF THESE GENERALIZED SOIL PROFILES IS FROM THE PRELIMINARY DRAFT OF THE NUT ISLAND FACILITIES PLAN, PREPARED BY METCALF & EDDY INC., APRIL 29, 1983.

LEGEND

▨ Sand & Gravel Fill
░ Sand
░ Organic Silt
☰ Marine Clay
Bedrock (Argillite)
Glacial Till

Figure 8.6
GENERALIZED SOIL PROFILE
NUT ISLAND

On-Island Water Transportation Facilities



NOTE
DATA FOR PREPARATION OF THESE GENERALIZED SOIL PROFILES IS FROM THE PRELIMINARY DRAFT OF THE NUT ISLAND FACILITIES PLAN, PREPARED BY METCALF & EDDY INC., APRIL 29, 1983.

LEGEND

- ░ Organic Silt
- ▒ Sand
- ☰ Marine Clay
- ◦ Glacial Till

Figure 8.7
GENERALIZED SOIL PROFILE
NUT ISLAND

On-Island Water Transportation Facilities

The surface elevation of the glacial drumlin till is quite variable. The till slopes downward, away from the drumlins and continues sloping beneath the water. Along the northeast margin of the peninsula the till is encountered at an elevation of about 55, 300 feet off shore. This is approximately 50 to 60 feet below the off shore ground surface. The surface of the till is of important engineering significance since glacial till would be the founding stratum for any contemplated pile foundations for piers.

- The glacial outwash deposit (principally marine clay) overlies the till. These deposits occur up as high as elevation 0 but the surface is generally lower due to erosion. In areas along the northeast side of the peninsula the surface of this deposit is presently at about Elevation -11. This deposit wedges out near the drumlins as the drumlins protrude up through the outwash. The outwash consists principally of the Boston Blue Clay interlayered to some degree with sand lenses. Most of the deposit is medium stiff to stiff in consistency, although the surface may be further consolidated by oxidation and dessication in former geologic times. Engineering properties of the marine clay are discussed in the M&E Report and will not be given here.

- Soft organic silt (muck) with sand lenses overlie the Boston Blue Clay. These organic deposits are the decayed remains of vegetation mixed with silt, clay and fine sand and formed in tidal marsh land when the relative sea level was lower than today. The organic silts are highly compressible soils of very low strength.

8.3 GEOTECHNICAL CONDITIONS AT THE PROPOSED PIER LOCATIONS

Fixed pier structures projecting offshore at both sites will require pile support. Neither the soft organic soils nor the marine clays are recommended for structural support of the proposed piers. Support for pile foundations will be developed in the very dense glacial till

underlying the organic soils and clay strata. Piles should behave as end bearing foundations in the upper few feet of glacial till.

In order to define pile lengths for final design, a series of borings will be required at both pier locations (Nut Island and Deer Island) along the applicable pier alignments. All borings should extend well into glacial till and occassional borings should be taken to bedrock.

The pile sections to be driven could consist of either displacement types such as prestressed concrete or closed end steel pipe, or low displacement type such as Steel "H" section or open end steel pipe. At the present time, prestressed concrete piling enjoys a price advantage over most other sections in the loading range of 100 to 150 tons.

Efficient installation of any of the pile sections may be accomplished with a properly selected impact hammer. Consideration was given to the use of vibratory hammers for noise reduction aspects. These hammers are not recommended because of imcompatability with the cohesive clay strata at the proposed sites through which the piles must penetrate. Vibratory hammers perform most efficiently in saturated cohesionless soils such as sands in which the oscillatory pile driving movement induces localized liquefaction or fluidization of the soil. This effect does not occur with stiff cohesive soils such as the Boston Blue Clay. Additionally some penetration into the glacial till would be required and it is believed that vibratory methods would encounter premature refusal in this material.

Pile driving noise mitigation methods such as exhaust mufflers and enclosures for impact hammers are discussed elsewhere in this report.

Deck elevations for the piers are anticipated to be at about +16. Pile cut off elevations are therefore approximately +13 or +14.

Driven displacement piles should take up in the top few feet of glacial till. At Deer Island, this will result in piles of lengths ranging from about 65 to 100 feet in length. Piles at the Nut Island

site will vary from about 55 to 80 feet in length. If non-displacement piles are utilized at either site, the lengths may be greater by a few feet per pile.

The following references were used to prepare this Geotechnical Evaluation:

- Billings, M.P., 1976, Geology of the Boston Basin:
  Geological Society of America, Memoir 146, p.5-30.

- Goldberg-Zoino and Associates, Inc., November 1983
  Geotechnical Data Report, Deer Island Treatment Plant Facilities Plan:
  Metropolitan District Commission, p1-13, Tables and Appendices

- Kaye, C.A., 1982, Bedrock and Quaternary Geology of the Boston Area, Massachusetts:
  Geological Society of America, Reviews in Engineering Geology, Volume V, p.25-40.

- LaForge, L., 1932, Geology of the Boston Area, Massachusetts:
  U.S. Geological Survey Bulletin 839, Plates 1 and 2.

- Metcalf and Eddy, Inc., April 29, 1983, Nut Island Facilities Plan, Preliminary Draft:
  Metropolitan District Commission, Chapter 4 and Appendix C.

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THE MAGUIRE
GROUP
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[illegible]

July 14, 1986
CEM #11721

Massachusetts Water Resources Authority
20 Somerset Street, Fourth Floor
Boston, MA 02108

Attention: Kevin O'Brien, P.E.

Regarding: Geotechnical Factors at Deer Island and Nut Island Which Affect Pile Driving

Dear Mr. O'Brien:

Per your request of July 11, 1986, I have drafted this letter concerning the geotechnical factors that affect pile driving at Deer and Nut Islands.

These are two basic methods for driving piles in a water-based setting -- vibratory and impact hammers. These methods are influenced by the soil conditions found at a construction area. In the case of Deer and Nut Islands the soil conditions are described below and depicted on the attached figures.

The stratification at Deer Island from the bedrock upward is as follows: Bedrock which consist of Cambridge argellite was found in borings near the existing treatment plant at elevation -134 and at locations east of Deer Island. East of the pier site rock has been encountered at between elevation -40 to -60, illustrating considerable relief in the rock surface.

Overlying the bedrock is a layer of glacial till of varying thickness. The glacial till is composed of very dense sand, gravel, silt, clay, cobbles and boulders, and forms much of the Deer Island landform. The till slopes upward toward the drumlin and presumably thickens in that direction as well.

The glacial outwash of silty marine clay overlies the glacial till. The marine clay surface slopes downward away from the shore and in general, the clay stratum thickens out into Boston Harbor. The marine clay is stiff in consistency.

Organic silt (muck) mixed with fine sand and shells overlies the stratum of marine clay. This deposit is very soft in consistency and possesses little engineering strength. The organic silt stratum is not present at all locations in the pier area.

Beach deposits and possible fill overlie the organic silt to some extent. The beach deposits of fine sand and deposits of sand and gravel are present near shore but appear to feather out and dissipate several hundred feet out. At this point the organic silt forms the uppermost stratum. Beach deposits and fill are on the order of 15 feet thick over the organic silt at the Shore and are thicker toward the inland areas.

The stratification at Nut Island from the bedrock upward is generally as follows and depicted on the attached figures: The bedrock which underlies the site consists of Cambridge argellite. At the Nut Island Pennsula the argellite is generally dark gray and moderately hard. The surface of the rock is at about elevation -50 to -60 and it deepens toward the north and east. The bedding planes in the argellite are steeply inclined, indicating considerable folding of the stratum in the geologic past.

Glacial till overlies the bedrock. The till is composed of a heterogeneous mixture of clay, sand and gravel and silt, with scattered cobbles and boulders. The till is very dense in consistancy.

The surface elevation of the glacial till is quite variable. The till slopes downward, away from the drumlins and continues sloping beneath the water. The surface of the till is of engineering significance since glacial till would be the founding stratum for any contemplated pile foundations for piers.

The glacial outwash deposit (principally marine clay) overlies the till. This deposit wedges out near the drumlins as the drumlins protrude up through the outwash. The outwash consists principally of the Boston Blue Clay interlayered to some degree with sand lenses. Most of the deposit is medium stiff to stiff in consistency, although the surface may be further consolidated by oxidation and dessication in former geologic times.

Soft organic silt (muck) with sand lenses overlie the Boston Blue Clay. These organic deposits are the decayed remains of vegetation mixed with silt, clay and fine sand and formed in tidal marsh land when the relative sea level was lower than today. The organic silts are highly compressible soils of very low strength.

There are basically two characteristics of the soils at both Deer and Nut Islands which cause vibratory methods to be ineffective. The first is the presence of the thick deposit of Boston Blue Clay through which the foundation piles must penetrate. Vibratory hammers rely on oscillations in the range of 20 to 40 Hz to fluidize or liquefy the soil around the pile and thereby reduce side friction on the shaft of the pile. This effect will only occur in granular (sandy) soils at these frequencies. In fine grained cohesive soils (clays) there is no liquefying effect and the pile does not advance.

The second characteristic of the island sites unfavorable to vibratory pile driving is the nature of the bearing stratum. Piles will end bear in glacial till which is a very dense heterogeneous mix of sand, gravel, silt, clay and cobbles. Piles will encounter premature refusal in this stratum if advanced with vibratory hammers.

Impact hammers function in a very different manner from the low frequency vibrators in that a stress wave (due to impact at the pile top) is caused to travel downward to the pile tip and impart energy to the soil. This results in soil displacement and an incremental advance of the pile without relying on liquefaction of the soil by vibration.

Should you have any questions about these matters, CE Maguire is prepared to discuss them with you at your convenience.

Very truly yours,

CE MAGUIRE, INC.

Jeffrey M. Paul

Jeffrey M. Paul
Deputy Project Director

JMP/cm

cc: D. O'Brien - MWRA
R. Brown - CEM
P. Malone - CEM
C. Mason - CEM
A. Prata - CEM
K. Schoellner - CEM
M. Shamon - CEM
R. Tong - CEM

7.4 PILE DRIVING EQUIPMENT

7.4.1 Introduction

This portion of the environmental analysis determined noise impacts due to the pile driving phase of construction for the piers at Deer and Nut Islands. Accordingly, the following steps were taken 1) noise measurements were made near the closest residences to the pier construction sites, 2) future noise levels due to pile driving were computed for these receptors, and 3) noise mitigation measures were identified.

7.4.2 Noise Measurement Results

Daytime noise measurements were made on July 1, 1986 at the closest residences to the Deer and Nut Island construction sites. (Pile driving will not be performed at night.) A comparison of measurement data with that from previous studies is presented in Table 7.4-1. The recent results exhibit slightly lower noise levels in some instances. Because use of lower ambient noise levels tends to produce a more pessimistic noise assessment, the recent data will be used in this report.

7.4.3 Noise Impact Assessment Criteria

Noise impact is judged according to two criteria: (1) the extent to which specific governmental laws or regulations are exceeded, and (2) the estimated extent to which people will be adversely affected.

The extent of noise impact on human receptors from a proposed project is proportional to a number of interrelated factors, including: the change in noise levels; the duration and character of noise, the

TABLE 7.4-1

NOISE MEASUREMENT RESULTS (dBA)

Project Location	Noise Metric	Start Time	Current Measurements	Start Time	Previous Measurements
Deer Island	L90	9:12 am	51	9:00 am	52*
	L10		69		77*
	Leq		67		75*
	L90	1:01 pm	43	1:00 pm	51*
	L10		67		69*
	Leq		67		67*
Nut Island	L90	10:38 am	49	--	--
	L10		53	--	--
	Leq		52	--	--
	L90	2:45 pm	47	1:30 pm	54**
	L10		55		56**
	Leq		56		55**

---

*Cavanaugh Tocci Associates, 1985.

**CE Maguire, Inc., 1984.

Note, measurement sample durations were as follows: 1986 data, 20 minutrs; 1985 data, 60 minutes; 1984 data, 8 minutes.

presence of existing, non-project noise sources; people's attitudes concerning the project (Stevens, Rosenblith, and Bolt 1955); the number of people exposed; and the type of human activity affected (sleep, recreation, or conversation).

The specific governmental regulations pertaining to the two project sites are the City of Boston Noise Regulations (Deer Island) and the Massachusetts Department of Environmental Quality Engineering (DEQE) community noise guidelines (both sites). The City of Quincy does not have regulations for limiting daytime construction noise.

Boston's noise regulation limits overall construction site noise and the noise emission of new construction equipment. However, pile driving noise is specifically excluded from both areas of the Boston regulation.

The DEQE community noise guidelines specify that a new facility shall not increase the background noise (L_{90}) by more than 10 dBA over that previously existing. L_{90} is the A-weighted noise level exceeded 90 percent of a given time period. (The Appendix contains definitions of terms.) Conventional pile driving noise, because of its short duration impulsive character, does not change the background noise level.

Based upon the preceding considerations, there are no enforceable regulations for the construction noise from pile driving. As noted in the Final Environmental Impact Report, the goal of reducing the long-term noise impact associated with construction activity was established. The noise impact associated with pile driving would be reduced, if peak noise levels complied with DEQE community noise guidelines.

7.4.4 Noise Impacts

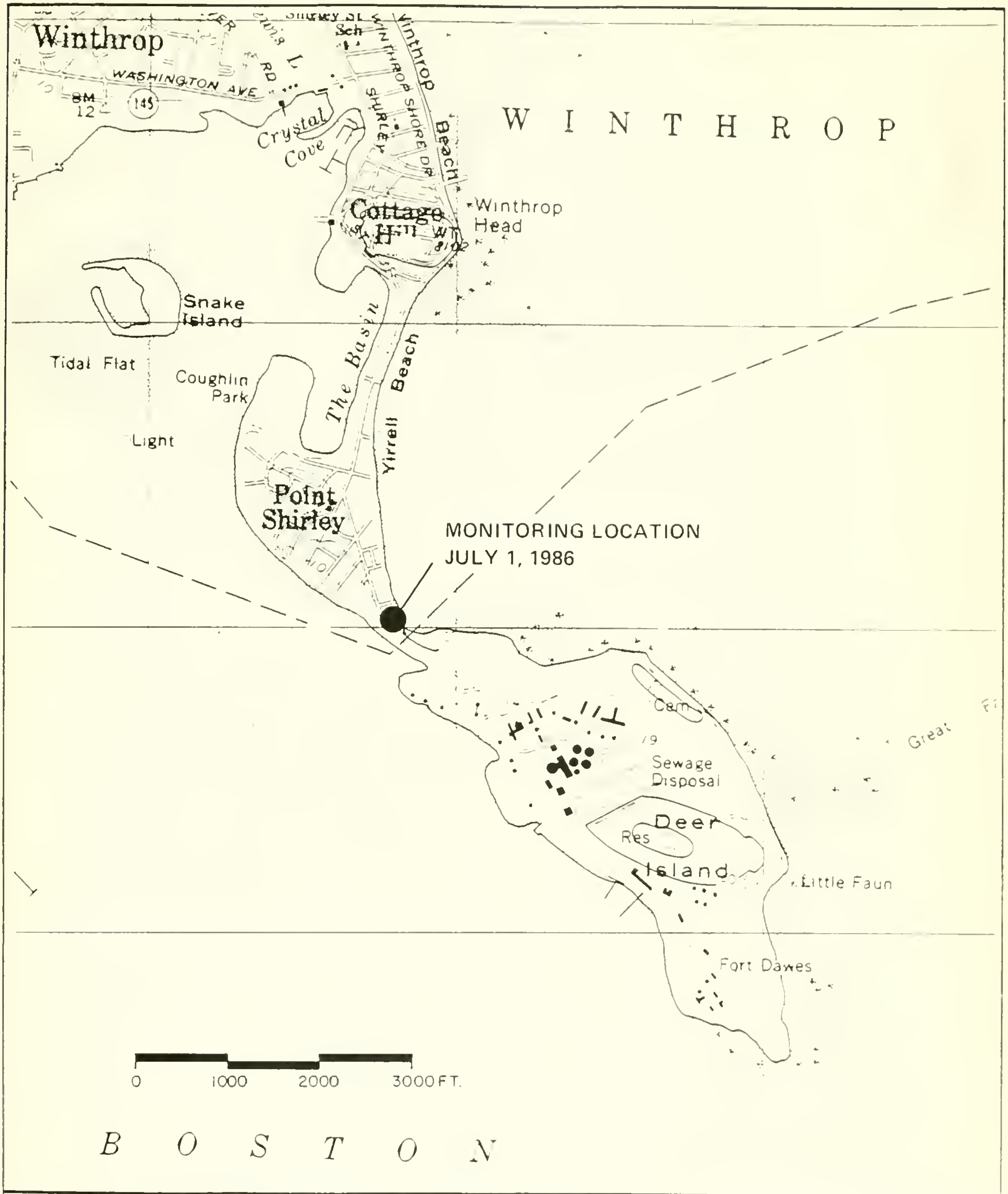
The noise emission levels of the pile driving operation is a function of the type and size of the piles and of the hammer used. A value of 101 dBA (the sound pressure level at 50 feet reference distance) is commonly used to characterize conventional impact pile driving noise

emission (EPA 1971 and BBN 1974). This value essentially corresponds to the peak sound pressure level. The hammer blows typically are at a rate of approximately one per second, with the duration of the actual noise pulse of much shorter duration. Some construction noise impact assessment studies have employed the Leq (energy average) noise metric; the 101 dBA peak level corresponds to an Leq of approximately 87 dBA (EPA 1971).

For the purposes of assessing the impact of pile driving noise on the nearest residents to the Deer Island and Nut Island projects, the peak sound pressure level metric is considered more appropriate, and will be employed for this report. Other sound propagation conditions employed were closest-residence-to-pile-driving distances of 4,000 feet and 1,200 feet for the Deer Island and Nut Island sites, respectively (See Figures 7.4-1 and 7.4-2). Atmospheric propagation losses were computed based upon standard day conditions (59°F and 70% R.H.) and pile driving active band spectrum per EPA 1971.

Table 7.4-2 presents a comparison of existing and pile driving noise levels evaluated at the nearest residences to the pile driving areas. This data shows that the pile driving noise impacts at Deer Island are not expected to be significant. The noise amplitude is only slightly above the lowest daytime background noise level; if a resident were outdoors, they would be able to occasionally hear pile driving noise. Thus, pile driving at Deer Island is not expected to cause annoyance to residents.

Based upon local input received at the July 17, 1986 meeting of the Quincy Citizens Advisory Committee (CAC), a short pier location on the northeast side of Nut Island is being further investigated. Location of the pier on the northeast side of Nut Island would reduce pile driving noise at the closest residences by approximately 2 dBA. This is due to the increase in distance from the pier.



MONITORING LOCATION
JULY 1, 1986

Figure 7.4-1
BACKGROUND NOISE SAMPLING STATION
DEER ISLAND

On-Island Water Transportation Facilities

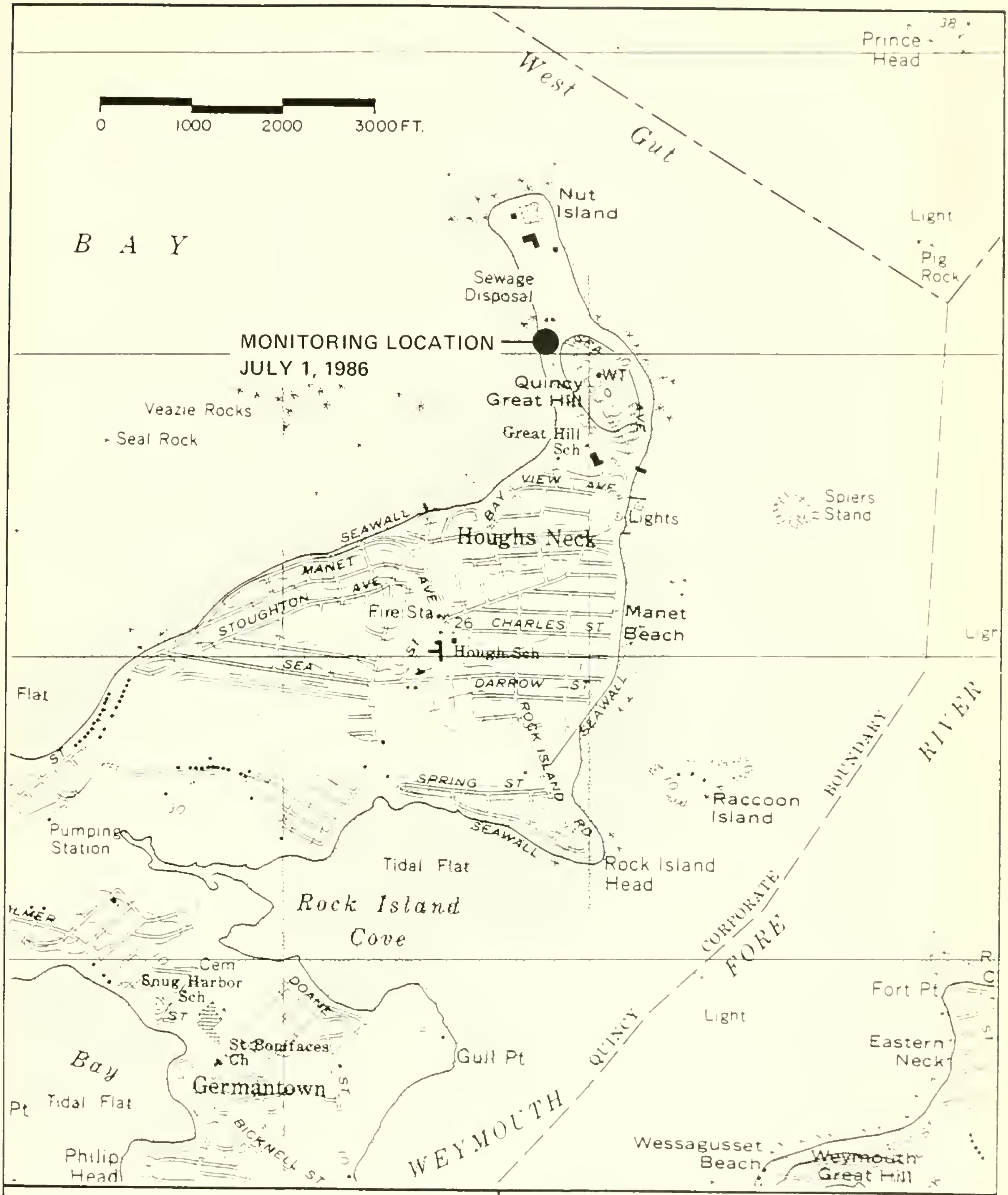


Figure 7.4-2
BACKGROUND NOISE SAMPLING STATION
NUT ISLAND

On-Island Water Transportation Facilities

TABLE 7.4-2

DAYTIME OUTDOOR NOISE FROM CONVENTIONAL PILE DRIVING (dBA)

EVALUATED AT NEAREST RESIDENCES TO PROJECT SITES

Project Site	Existing Noise Levels		Pile Driving Noise Level	Pile Driving Noise Increment*	
	L90	Leq	Peak	L90	Leq
Deer Island	43	67	47	4	--
Nut Island	47	56	66	19	10

---

*Increments are peak pile driving noise levels above the L90 and Leq existing noise levels.

At Nut Island, pile driving noise levels would generally represent the predominate source of community noise and a possible source of annoyance to some residents in terms of affecting leisure use of outdoors. A review of various noise mitigation methods presented in the next section shows that it would be possible to reduce noise impacts at Nut Island to a degree acceptable to residents.

7.4.5 Mitigation Measures

A number of possible approaches exist for mitigating pile driving noise impacts:

- Scheduling during cold weather. Confining pile driving activity to the cold weather months, when people normally spend more time indoors, would reduce the number of people impacted. The typical range of residential building wall attenuation (with windows closed) is approximately 20 to 25 dBA. For the closest residents to Nut Island, this would mean maximum interior noise levels in the range or 41 to 46 dBA, which would generally not be expected to interfere with daytime activities.

- Increased number of pile drivers. By employing two pile drivers on the construction site, the overall period of pile driving activity could be approximately halved. For example, preliminary estimates indicate that approximately 260 concrete piles will be required at Nut Island, and that the average installation rate would be 4 piles per driver per day. Using these assumptions would mean that the total period of pile driving activity could be reduced from 3 months to 1.5 months by using two pile drivers. Use of two pile drivers would mean that at times both drivers would be operating simultaneously. Resulting peak noise levels (for coincident hammer blows) would be three dBA higher than the noise due to a single driver. A three dBA increase in noise level would be barely noticeable, whereas the halving of the pile driving activity period would represent a significant reduction in noise impact. Use of two pile drivers would also facilitate use of cold weather scheduling.

* Use vibratory pile driving methods. Use of vibratory or sonic pile driving methods essentially eliminates impact noise and the conventional diesel or gasoline engine power source becomes the primary source of noise. Unfortunately, use of vibratory pile driving for this project is not considered feasible due to unfavorable soil conditions.

* Use bottom driving method. In the bottom driving method the hammer blows are applied to a plug in the bottom of the drive tube, resulting in the tube being "pulled" into the soil. This method has been described as reducing pile pile driving noise to ". . . that of a well-muffled diesel engine." (Franki Foundation Company publication 2.2a Fr).

* Use noise control methods in the vicinity of the pile driver. Special noise control measures can be designed to reduce the noise from conventional pile driving. For example the hammer exhaust noise could be reduced by means of a silencer. Noise from both the hammer impact and the exhaust could be reduced by a moveable shroud, enclosing the pile hammer. Such methods have been found to be effective in reducing the noise from conventional pile driving to 10 to 20 dBA. The cost and difficulty of pile driving would increase with the degree of noise reduction.

7.4.6 Recommendations

Since pile driving for the Deer Island pier is anticipated to result in negligible noise impacts, no special noise control measures are needed. At Nut Island, pile driving noise is predicted to cause some degree of noise impact and noise mitigation is desirable. It is recommended that several noise control measures be employed. First, use of two pile drivers will reduce the overall duration of pile driving from 3 to 1.5 months. Scheduling the operation to coincide with cold weather would be of significant benefit in reducing noise impacts to an acceptable degree. If such scheduling is not possible, then measures should be taken to reduce the noise emission from the pile drivers by about 10 dBA. Such a reduction is believed to be relatively easy and economical to implement and would not result in an appreciable slowing down of pile driving.

REFERENCES

Stevens, K.N., W.A. Rosenblith, and R.H. Bolt 1955. A Community's Reaction to Noise: Can It Be Forecast? Noise Control 1 (1):63-71.

EPA 1971. Noise From Construction Equipment And Operations, Building Equipment, And Home Appliances. U.S. EPA report NTID300.1. December 31, 1971.

BBN 1974. Regulation of Construction Activity Noise. BBN Report No. 2887, November 27, 1974.

FEIR 1985. Final Environmental Impact Report On Siting of Wastewater Treatment Facilities For Boston Harbor. Massachusetts Water Resources Authority. November 1985.

SEDIMENT SAMPLING PLAN FOR SITE ACCESS FACILITIES CONSTRUCTION AT DEER ISLAND AND NUT ISLAND

The construction of new wastewater treatment facilities at Deer Island to serve Metropolitan Boston will require the construction of permanent piers, docks and moorings at Deer Island and Nut Island.

On Friday, February 28, 1986 the MWRA filed an ENF for the permanent facilities.

Interim sludge disposal facilities may require marine construction (temporary docks, piers and /or dredging) to provide barge access to Deer and Nut Islands. At Deer Island, permanent docks for plant construction will be kept separate from temporary facilities for interim sludge disposal. Included herein is a suggested sediment sampling program to be used in the environmental analysis of the proposed site access facilities at both Deer and Nut Island.

This marine construction will require a U.S. Army Corps of Engineers Section 404 - Section 10 permit. A U.S. Army Corps of Engineers Section 103 permit may also be required if dredging is required, and spoils are to be disposed at sea. State and local permits also anticipated include: Massachusetts Division of Water Pollution Control Water Quality Certificate; Massachusetts Division of Waterways License; Massachusetts Coastal Zone Management Consistency Determination; and a local wetlands permit. Reports will evaluate the environmental impacts that may occur at the dock sites on Deer Island and Nut Island and at the Dredge Material Disposal Site. The MWRA's consultants will collect and analyze existing information, and, where necessary, collect additional data in order to clearly define the potential for adverse environmental impacts. This information will be used to develop mitigating measures, where appropriate.

The specific impacts of the proposed construction action may occur at the waterfront of Deer Island and Nut Island and at the Boston Dredged Material Disposal Site, if dredging is required. At the present, preliminary design data suggests that dredging will not be required for permenant docks/piers at Deer Island. Predominant effects at the construction site on the Islands will be short-term water quality impacts resulting from resuspension of sediments during dock and pier construction. Short-term environmental impacts may be experienced at the Dredged Material Disposal Site as a result of the discharge of dredge spoils.

In order to assess the effects of dock construction, studies will be undertaken to: evaluate existing information concerning water quality and sediment chemistry at the proposed dock sites, collect additional data at the sites, and perform an ecological assessment of the effects of oceanic disposal of dredged material from the sites. In order to facilitate completion of the reports, these tasks will be performed.

1. The first suggested task will be collection and analysis of existing data (both published and unpublished) from the area surrounding Deer Island. The data acquisition will include existing information pertaining to sedimentology, geochemistry, bathymetry, water quality and ecology of the area. Some information already exists (Appendix A) concerning the physical and chemical characteristics of the project area. Bathymetry data is available for the dock sites on Deer Island. Bathymetry data will be developed for Nut Island.

2. The second suggested task will be the review and finalization of the sediment sampling program with environmental permitting and review agencies including:

   - U.S. Army Corps of Engineers
   - U.S. Environmental Protection Agency
   - U.S. Fish and Wildlife Service
   - National Marine Fisheries Service
   - Massachusetts Department of Environmental Quality Engineering
     - Division of Water Pollution Control
     - Division of Waterways
   - Massachusetts Department of Environmental Management
     - Massachusetts Environmental Policy Act Unit
     - Coastal Zone Management
     - Division of Marine Fisheries
     - Division of Solid and Hazardous Waste

3. The third suggested task will be an additional chemical/physical characterization of Deer Island and Nut Island sediments. Suggested sampling program is summarized in Tables 1 and 2. It is suggested that continuous, undisturbed gravity core samples will be collected to depth (or refusal) at sixteen locations at Deer Island (Figures 1 and 2) and six locations at Nut Island (Figure 3). Visual descriptions of the sediment horizons will be done for all core samples (these are called "tube logs"). For each core, samples will be extracted from each horizon (with elutriate) and be retained in refrigerated storage for subsequent analysis, as required. Based on the tube logs, the portion of each core lying above virgin marine clay will be composited (one verticle composite per core). At the permanent dock locations twelve vertical composites and four surface (top 6") grab samples will each be tested for bulk sediment chemistry (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, PCB's, oil and grease and other constituents requested by state or federal authorities). At the temporary facility site on Deer Island, it is suggested that four composited samples and one surface grab sample be tested for these bulk sediment parameters.

It is suggested that these samples will be tested for standard physical parameters (percent volatile solids, percent water, grain-size distribution, specific gravity).

At the permanent facility site on Deer Island, it is suggested that one elutriate test be done on a composite of cores from DIS-5 and DIS-6. A second elutriate analysis will be done on DI-1. All elutriate and ambient water tests will be performed in triplicate.

At the temporary facility site on Deer Island one elutriate test is suggested for a composite from all ten cores.

At Nut Island, one elutriate test is suggested for a composite from NI-1 and NI-3. Another elutriate test is suggested for NI-4 and NI-6.

This information will be used to address the questions of potential impact at the construction sites. Results of these tests and other recent analyses will be evaluated in the context of published operational limits for sediment classification (Massachusetts Division of Water Pollution Control, 1978, New England River Basins Commission, 1980) and current water quality criteria for the protection of saltwater aquatic life (U.S.EPA, 1976, Federal Register 11/20/80, 8/13/81, 2/15/84 and 314 CMR 4.03).

4. The fourth suggested task consists of a series of bioassay and bioaccumulation tests to assess the impact of dredged material disposal on marine organisms.

   While dredging and dredge spoils disposal does not appear necessary at the permanent facility site on Deer Island, bioassay/bioaccumulation studies are suggested in case detailed engineering studies show a need for dredging. Composite samples will be used for bioassay/bioaccumulation tests at each site. Suggested sampling stations selected for bioassay/bioaccumulation composites correspond to the areas where dredging may occur. Each of the cores selected will be vertically composited to the depth of potential dredging or core refusal. Suggested stations to be composited for bioassay/bioaccumulation test are:

   - Deer Island Permanent Facility
     DIS-5, DIS-6 (DIS-4 if silty or organic material is found)
   - Deer Island Termporary Facility
     All Ten Stations

- Nut Island Permanent / Temporary Facility
  - All Six Stations

These tests will be performed according to methods of the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency (1977), and will be used to compare the characteristics of the material to the characteristics of material from a reference area located outside the boundary of the disposal sites. It is assumed that a bioassay/bioaccumulation study will be required for ocean disposal of any dredged material. Because of the relatively long time necessary to perform this type of analysis (routinely 60 to 90 days), and the additional time required for regulatory review, it is proposed to initiate this evaluation as soon as possible in order for the MWRA and its consultants to complete their reports in accordance with the Court ordered schedule.

5. Under the fifth task, it is suggested that sediments will be tested for the presence of hazardous waste using EPA's EP Toxicity method. Cores will be vertically composited to the depth of potential dredging. Tests will then be made on the following samples:

- Deer Island Permanent Facilities:
  - DIS-5 and DIS-6 (composite)
  - DIS-4
  - DIS-1
- Deer Island Temporary Facilities:
  - All Ten Stations (composite)
- Nut Island Permanent / Temporary Facilities
  - NI-2
  - NI-4
  - NI-6

EPA's EP Toxicity test analyzes a sample for the following parameters: As, Ba, Cd, Cr, Pb, Hg, Se, Ag, endrin, lindane, methoxychor, toxaphene, 2,4 D and 2,4,5 TP (silvex). The results of the EP Toxicity tests will be compared with the Resource Conservation and Recovery Acts (RCRA) criteria for hazardous waste. The results will help determine whether or not the sediment is suitable for disposal on land.

Samples tested for the parameters of EP Toxicity will also be tested for sodium and chloride using the EP Toxicity extraction procedure .

6. The sixth suggested task is the collection of surface grab samples for macrobenthic identification and count.

Samples will be collected and seived (0.595 mm screen) at Stations DIS-1, DIS-6, DIN-5, and NI-2. Macrobenthic organisms will be counted, and identified to species level where possible, and to the genus level otherwise.

NOTES

TABLE 1 AND TABLE 2

(1) Bulk Sediment Physical Analysis:

percent water, percent volatile solids, grain size (seive and hydrometer), specific gravity.

(2) Bulk Sediment Chemical Analysis:

As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, PCB (total), Oil & Grease.

(3) Elutriate and Control (Sea Water) Analysis:

As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, PCB (total), Oil & Grease.

(4) Solid Phase Bioassay:

Grass Shrimp, Hard Clams, Sand Worms

Bioaccumulation:

(same organisms as bioassay) testing for Cd, Hg, PCBs, DDT family and aromatic hydrocarbons.

(5) EPA EP Toxicity:

As, Ba, Cd, Cr, Pb, Hg, Se, Ag, endrin, lindane, methoxychor, toxaphene, 2,4 D and 2,4,5 TP (Silvex).

TABLE 1

SUGGESTED SEDIMENT SAMPLING PROGRAM

DEER ISLAND

Parameter	Permanent Facilities South Site	Temporary Facilities North Site
1. Number of Sample Locations	6 (DIS-1 to DIS-6)	10 (DIN-1 to DIN-10)
2. Sample Type	Continuous Undisturbed Core to Project Depth (or refusal) (DIS-1 to DIS-6)	Continuous Undisturbed Core to Project Depth (or refusal) (DIN-1 to DIN-10)
3. Core Description	Tube Log with Sediment Horizons for All Cores (DIS-1 to DIS-6)	Tube Log with Sediment Horizons for All Cores (DIN-1 to DIN-10)
4. Bulk Sediment Analysis A. Physical (See Note 1) B. Chemical (See Note 2)	8 Analyses: . 1 for Each Core, Consisting of Vertical Composite of Core Lying Above Virgin Marine Clay (DIS-1 to DIS-6), and . two surface grab samples (DIS-5 and DIS-1)	5 Analyses: Composites from: . DIN-1, DIN-2, DIN-3 . DIN-4, DIN-5, DIN-6 . DIN-7, DIN-8 . DIN-9, DIN-10 Each Core Consisting of Vertical Composite of Core Lying Above Virgin Marine Clay, and . one composite of surface grab samples from: DIN-4, DIN-5, DIN-6
5. Elutriate Analysis (See Note 3)	2 Elutriate Analyses: . Composite of DIS-5 and DIS-6 . DIS-1 (both using vertical composite of core above virgin marine clay)	1 Elutriate Analysis: Composites from DIN-1 through DIN-10. (using vertical composite of core above virgin marine clay)
6. Bioassay/Bioaccumulation (See Note 4)	1 Analysis: Composite from DIS-5 and DIS-6, and DIS-4 if found to contain silt and/or organic material (each core vertically composited to depth of potential dredging)	1 Analysis: Composite from DIN-1 through DIN-10 (each core vertically composited to depth of potential dredging)
7. EP Toxicity, Na, Cl^- (See Note 5)	3 Analyses: . Composite from DIS-5 and DIS-6 . DIS-4 . DIS-1 (each core vertically composited to depth of potential dredging)	1 Analysis: Composites from: . DIN-1 through DIN-10
8. Macrobentic Identification and Count	Analysis of grab samples from DIS-1 and DIS-6	Analysis of grab samples of DIN-5

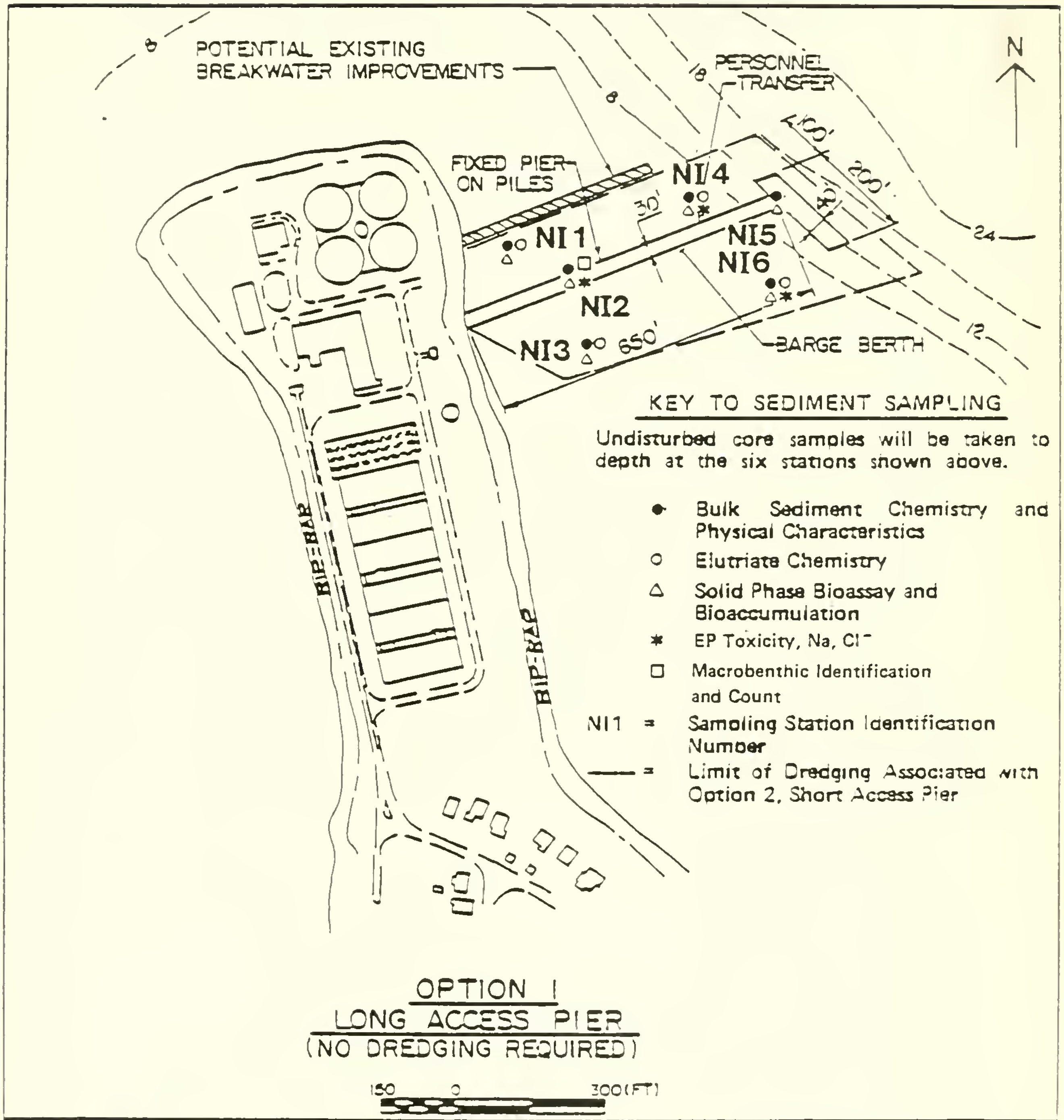
TABLE 2
SUGGESTED SEDIMENT SAMPLING PROGRAM
Nut ISLAND

Parameter	Permanent / Temporary Facilities
1. Number of Sample Locations	6 (NI-1 to NI-6)
2. Sample Type	Continuous Undisturbed Core to Project Depth (or refusal) (NI-1 to NI-6)
3. Core Description	Tube Log with Sediment horizons for all Cores (NI-1 to NI-6)
4. Bulk Sediment Analysis A. Physical (See Note 1) B. Chemical (See Note 2)	8 Analyses: . 1 for Each Core, Consisting of Vertical Composite of Core Lying Above Virgin Marine Clay (NI-1 to NI-6), and . two surface grab samples from N1-2 and N1-4
5. Elutriate Analysis (See Note 3)	2 Elutriate Analyses: Composites from: . NI-1 and NI-3, . NI-4 and NI-6 (both using vertical composite of core above virgin marine clay)
6. Bioassay/Bioaccumulation (See Note 4)	1 Analysis: Composite from All Six Cores (each core vertically composited to depth of potential dredging)
7. EP Toxicty, Na, Cl^- (See Note 5)	3 Analysis: . NI-2 . NI-4 . NI-6 (each core vertically composited to depth of potential dredging)
8. Macrobenthic Identification and Count	Analysis of grab samples from NI-2

SUMMARY

PROPOSED SEDIMENT SAMPLING PROGRAM
NUMBER OF SAMPLES BY TYPE AND SITE

	DEER ISLAND		NUT ISLAND
Parameter	Permanent	Temporary	Permanent / Temporary
Number of Sampling Stations	6 DIS-1 to DIS-6	10 DIN-1 to DIN-10	6 NI-1 to NI-6
Core Description (Tube Logs w/Sediment Horizons)	6 DIS-1 to DIS-6	10 DIN-1 to DIN-10	6 NI-1 to NI-6
Bulk Sediment (Physical & Chemical)	6 DIS-1 to DIS-6	1 DIN-1 to DIN-10	6 NI-1 to NI-6
Elutriate	2 . DIS-5 + DIS-6 . DIS-1	1 DIN-1 to DIN-10	2 . NI-1 + NI-3 . NI-4 + NI-6
Bioassay/ Bioaccumulation	1 DIS-4 + DIS-5 +DIS-6	1 DIN-1 to DIN-10	1 NI-1 to NI-6
EP Toxicity	3 . DIS-5 + DIS-6 . DIS-4 . DIS-1	1 DIN-1 to DIN-10	3 . NI-2 . NI-4 . NI-6


POTENTIAL EXISTING BREAKWATER IMPROVEMENTS
PERSONNEL TRANSFER
N
FIXED PIER ON PILES
NI 4
NI 1
NI 2
NI 3
NI 5
NI 6
30'
650'
400'
200'
40'
BARGE BERTH
RIP-RAP
RIP-RAP
6
8
18
24
12
KEY TO SEDIMENT SAMPLING
Undisturbed core samples will be taken to depth at the six stations shown above.
● Bulk Sediment Chemistry and Physical Characteristics
○ Elutriate Chemistry
△ Solid Phase Bioassay and Bioaccumulation
✱ EP Toxicity, Na, Cl⁻
☐ Macrobenthic Identification and Count
NI1 = Sampling Station Identification Number
—— = Limit of Dredging Associated with Option 2, Short Access Pier
150 0 300 (FT)

OPTION 1
LONG ACCESS PIER
(NO DREDGING REQUIRED)

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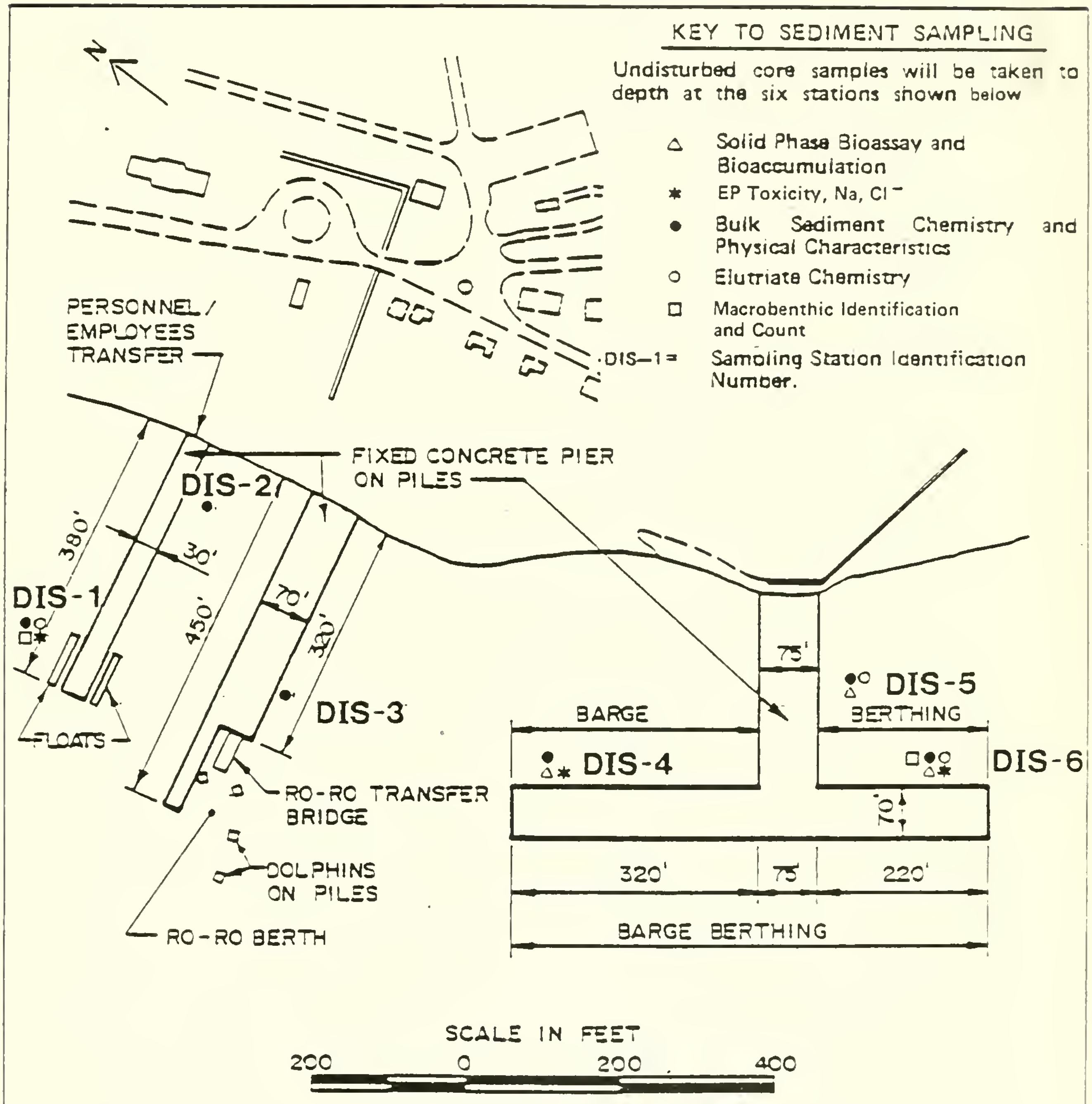
March, 1986

MWRA
NUT ISLAND
TEMPORARY AND PERMANENT FACILITY
PROPOSED SEDIMENT SAMPLING

FIGURE 3



KEY TO SEDIMENT SAMPLING

Undisturbed core samples will be taken to depth at the six stations shown below

△	Solid Phase Bioassay and Bioaccumulation
✱	EP Toxicity, Na, Cl⁻
●	Bulk Sediment Chemistry and Physical Characteristics
○	Elutriate Chemistry
☐	Macrobenthic Identification and Count
·DIS–1 =	Sampling Station Identification Number.

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March, 1986

MWRA
DEER ISLAND
PERMANENT FACILITY
PROPOSED
SEDIMENT SAMPLING

FIGURE 1

Property of
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ECOLOGICAL EVALUATION OF PROPOSED OCEANIC DISCHARGE OF DREDGED MATERIAL FROM DEER ISLAND AND NUT ISLAND

- DRAFT FINAL REPORT -

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June 1986

SUMMARY

The proposed oceanic discharge of dredged material from Deer Island and Nut Island is ecologically acceptable as judged by the toxicity criteria employed in this evaluation. Survival of grass shrimp (*Palaemonetes pugio*), hard clams (*Mercenaria mercenaria*), and sandworms (*Nereis virens*) exposed for 10 days to reference sediment and the solid phase of dredged material was not significantly different.

Tissues of grass shrimp, hard clams, and sandworms that survived exposure to the solid phase of dredged material did not contain significantly elevated (0.05 probability level) concentrations of xenobiotic constituents (cadmium, mercury, PCBs, DDT, and aromatic hydrocarbons) as compared to tissues of reference organisms.

TABLE OF CONTENTS

Section		Page
	SUMMARY	i
1.	INTRODUCTION	1
2.	METHODS AND MATERIALS	3
3.	RESULTS	11
	3.1 Solid Phase Bioassays	11
	3.2 Bioaccumulation Studies	14
	3.3 Physical, Chemical, and Taxonomic Evaluation of Sediment	14
4.	REFERENCES	25

Appendix

A. LABORATORY PROCEDURES FOR PREPARING DREDGED MATERIAL AND CONDUCTING BIOASSAYS

B. RAW BIOASSAY DATA

C. QUALITY CONTROL/QUALITY ASSURANCE DATA

The evaluation consists of four principal sections in addition to the Introduction. The first section, which precedes the Introduction, summarizes the ecological acceptability of the proposed discharge operation. The second section reviews the methods and materials employed in the evaluation. The third section presents important results of the evaluation. The fourth section contains references cited in the evaluation.

The evaluation contains three appendices. Appendix A details laboratory procedures employed for preparing dredged material and conducting bioassays. The appendix also serves as a quality-control document. Appendix B contains all raw bioassay data. Only data directly relevant to the ecological evaluation of the proposed discharge operation are presented in the main body of the report. Appendix C presents quality control and quality assurance information.

2. METHODS AND MATERIALS

Dredged material was collected from three areas -- the southern site at Deer Island (Sampling Stations DIS-1 to DIS-6), the northern site at Deer Island (Sampling Stations DIN-1 to DIN-10), and at Nut Island (Sampling Stations NI-1 to NI-6). Material was collected by Robert Boeri, Jay McKay, and Jeanne Magazu, ERCO, during March 25-28, 1986.

Station locations are presented in Figure 1. A core sample was collected to project depth or to refusal at each station using a plastic-lined gravity corer. A description of each core sample and collection details are presented in Table 1. At each location the core sample was homogenized and subsampled into solvent-rinsed glass jars (organic analyses) or acid-soaked polyethylene jars or buckets (inorganic and bioassay analyses). Samples were maintained in an ice chest during transportation to ERCO's Aquatic Toxicology Laboratory in Cambridge, Massachusetts, where they were placed in cold storage at 2-4°C. Seawater for elutriate preparation was collected at each of the sampling sites -- DIS (Stations 1, 5, and 6), DIN (Stations 1-10), and NI (Stations 1, 3, 4, and 6). At all three locations, seawater from all stations was composited. At Stations DIS-1, DIS-6, DIN-5, and N1-2 a 1-liter sample of sediment was collected with a Van Veen grab sampler and sieved (0.5 mm) in the field. Organisms retained in the screen were preserved and identified.

Dredged material was prepared for biological testing according to procedures described in Appendix B of U.S. EPA and COE manual for dredged material (U.S. EPA and U.S. Army COE, 1977). Three composite samples of sediment were formulated for bioassays. The first sample (Sample DIS) consisted of sediment from Stations DIS-4, DIS-5, and DIS-6; the second sample (Sample

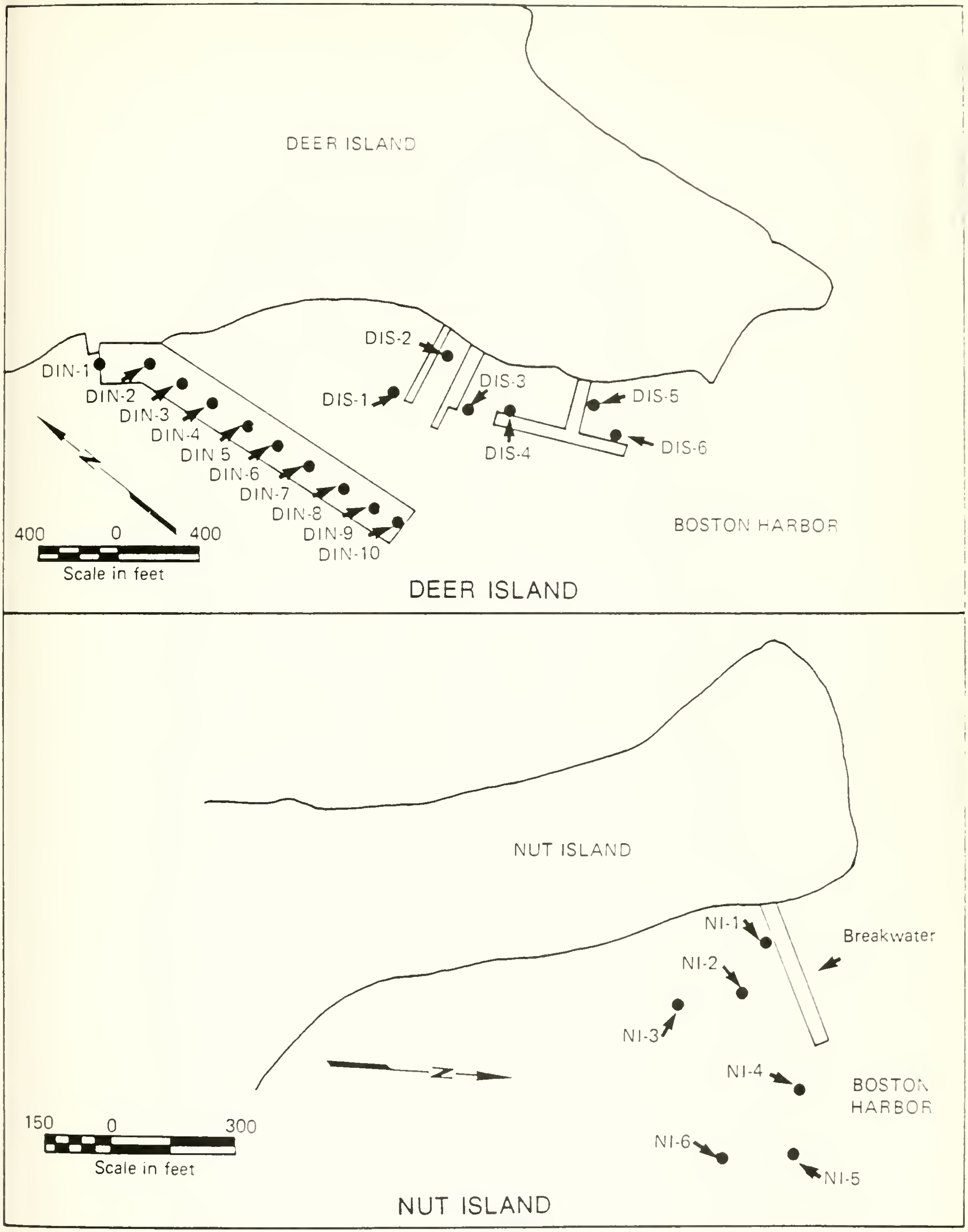

Figure 1. Location of sediment sampling stations at Deer Island and Nut Island.

Table 1. Details of sample collection and description of core samples collected at Deer Island and Nut Island

Sample Station	Time and Date of Collection		Water Depth	Core Length	Visual Description of Sediment
DIS-1	12:50	03/26/86	21 ft	3 ft 10 in	Black silt (4 in clay discarded)
DIS-2	11:10	03/28/86	23 ft	3 ft 10 in	Black silt
DIS-3	10:30	03/28/86	27 ft	4 ft	Black silt (1 in clay discarded)
DIS-4	11:10	03/26/86	52 ft	2 ft 5 in	Black silt
DIS-5	11:50	03/26/86	31 ft	2 ft 11 in	Black silt
DIS-6	09:50	03/26/86	50 ft	3 ft 9 in	Black silt over clay (1 ft 6 in clay discarded)
DIN-1	14:40	03/27/86	14 ft	2 ft 7 in	Black sandy silt with shells
DIN-2	15:10	03/27/86	9 ft	3 ft 10 in	Black silt
DIN-3	15:35	03/27/86	16 ft	3 ft 7 in	Black silt
DIN-4	15:55	03/27/86	15 ft	3 ft 9 in	Black silt with 3 in black detritus on surface
DIN-5	16:10	03/27/86	15 ft	3 ft 10 in	Black silt with 3 in black detritus on surface
DIN-6	08:35	03/28/86	14 ft	4 ft	Black silt (2 in clay discarded)
DIN-7	09:10	03/28/86	15 ft	3 ft 7 in	Black silt (12 in clay discarded)
DIN-8	09:20	03/28/86	16 ft	3 ft 8 in	Black silt
DIN-9	09:45	03/28/86	17 ft	3 ft 8 in	Black silt (1 in clay discarded)
DIN-10	10:00	03/28/86	23 ft	3 ft 10 in	Black silt
N1-1	10:45	03/25/86	12 ft	1 ft 4 in	Uniform silty sand with shells
N1-2	12:40	03/25/86	11 ft	3 ft 4 in	Uniform sandy silt
N1-3	13:10	03/25/86	10 ft	3 ft 10 in	Uniform sandy silt with shells
N1-4	13:50	03/25/86	10 ft	3 ft 9 in	Uniform sandy silt
N1-5	14:40	03/25/86	10 ft	4 ft 5 in	Uniform sandy silt
N1-6	15:20	03/25/86	7 ft	3 ft 8 in	Uniform sandy silt

DIN) consisted of sediment from Stations DIN-1 through DIN-10, and the third sample (Sample NI) consisted of sediment from Stations NI-1 through NI-6. Solid phase bioassays with dredged material were conducted according to guidelines presented in Appendix F of the EPA and COE manual for dredged material (U.S. EPA and U.S. Army COE, 1977).

Species tested in the solid phase bioassays were the grass shrimp (Palaemonetes pugio), hard clam (Mercenaria mercenaria), and sandworm (Nereis virens). Grass shrimp, hard clams, and sandworms were acquired from commercial suppliers and acclimated in artificial seawater for at least 3 days prior to initiation of testing. All species were tested in the same aquaria. Testing temperature was 20 ± 1°C. Water exchange (artificial seawater adjusted to a salinity of 30 ppt) was by the flow-through method. Control sediment employed in the tests was collected on March 27, 1986, from the subtidal zone off Manchester, Massachusetts. Reference (disposal-site) sediment used in the tests was collected on March 18, 1986, from a single sampling station located approximately 1.5 miles southeast of the "A" buoy in the Marblehead Foul Area. The sediment was collected with a Van Veen Grab Sampler.

At the conclusion of the solid phase bioassays with grass shrimp, hard clams, and sandworms, all surviving organisms from each aquarium were placed in an aquarium containing clean, sediment-free water and allowed to void their digestive systems (sandworms were confined in Nitex containers to prevent predation by grass shrimp). Organisms were maintained under flow-through conditions for a period of 2 days. During this time, fecal material was removed from aquaria. At the end of the 2-day period, all samples of organisms were split into approximately equal amounts. One of these subsamples was placed in a polyethylene clean bag and frozen for later analyses for metals. The second subsample was put in solvent-rinsed aluminum

foil and frozen for analyses for organics. Prior to being chemically analyzed, biological samples were thawed and shells of hard clams were removed with acid-rinsed plastic utensils (metal analyses) or solvent-rinsed metal utensils (organic analyses).

Biological samples (tissue samples) were analyzed for two metals -- cadmium (Cd) and mercury (Hg) -- according to procedures described by Goldberg (1976) and the EPA (1979). In the analyses for Cd, an aliquot of wet, homogenized tissue (approximately 5 g) was placed in a 100-ml tall-form Pyrex beaker with 5 ml of concentrated, Instra-analyzed (J.T. Baker Co.) nitric acid and refluxed without boiling until the tissue was completely digested (6-24 hr). Following digestion, the sample was evaporated to dryness. Then, additional nitric acid (1-2 ml) and 30% Ultrex (J.T. Baker Co.) hydrogen peroxide (1-2 ml) were added to the beaker, and the sample was heated until oxidative frothing subsided. At this time, the sample was cooled, diluted to volume with deionized, distilled water, and analyzed by graphite-furnace atomic absorption spectrophotometry (AAS). Procedural blanks and standards were evaluated using the same methods employed for tissue samples. For the analyses for Hg, a separate aliquot of wet, homogenized tissue (about 5 g) was placed in a 300-ml glass BOD bottle. Approximately 15-20 ml of concentrated, Instra-analyzed sulfuric acid was placed in the bottle and the sample was heated at 55°C in a water bath until the tissue was completely digested (2 hr). After cooling of the sample, 100 ml of deionized, distilled water and 1-2 g of Instra-analyzed potassium permanganate were added to the bottle. The resulting solution was analyzed by cold-vapor AAS after addition of reducing agents (10% hydroxylamine hydrochloride and 10% stannous sulfate). Procedural blanks and standards were assessed by the same methods used for tissue samples.

Tissue samples were analyzed for the three types of organics -- PCBs, DDT, and aromatic hydrocarbons -- according to procedures described by the U.S. EPA (1971), Crump-Wiesner et al. (1974), the U.S. Food and Drug Administration (1977), and Warner (1976). Tissue samples (5-20 g wet wt.) were placed in 50-ml centrifuge tubes, to which 10-ml aliquots of 10 N potassium hydroxide and high-purity methanol, and 5 µg of an internal standard (androstane) were added. After sealing with nitrogen gas, the tubes were placed in a water bath at 80°C for 4 hr (tubes were shaken every 30 min). This saponification process, described above, digested the tissue, thereby releasing PCBs, DDT, and hydrocarbons. Three 20-ml portions of high-purity hexane were used to extract the original compounds of interest from the methanol/potassium hydroxide digestate. The water fraction was then discarded. The three extracts were combined, dried over a small volume (10 g) of sodium sulfate, and concentrated to 1 ml by flash evaporation. The extracts were then fractionated using column chromatography (1 g sodium sulfate, 6.5 g of 7.5% deactivated alumina, and 1 g sodium sulfate) as follows. The 1-ml concentrate was charged to the top of the column and the column was eluted with 25 ml of hexane. The hexane was concentrated to 2 ml by flash evaporation, and further concentrated to 0.5 ml under a stream of purified nitrogen. The hexane fraction was analyzed for PCBs and DDT by packed-column gas chromatography and electron-capture detection, employing a Hewlett-Packard Model 5840A instrument equipped with a Ni^{63} detector. The column, a 6-ft x 2-mm I.D. glass instrument packed with 5% SP2401 or 1.95% SP2401 and 1.5% SP2250, was held isothermally at 188°C. The peaks in the hexane fraction were identified and quantified by comparing retention times and peak areas to those of standards. An aliquot of the column-chromatographic fraction was analyzed for aromatic hydrocarbons by glass capillary gas chromatography and flame ionization detection, employing a Hewlett-Packard Model 5840A instrument. The column, a 0.25-mm I.D. x 30-m SE30 glass

capillary fused silica column (J&W Scientific), was temperature-programmed from 60°C to 275°C at 10°/min. The areas of the resolved and unresolved components were measured by electronic integration and planimetry, respectively, and compared to the areas of an internal standard (androstane) to determine the concentration of hydrocarbons.

Results of the bioassay and bioaccumulation tests were interpreted by statistical techniques recommended by the U.S. EPA and U.S. Army COE (1977). When warranted, each data set generated in the studies was evaluated by Cochran's procedure to determine if variances of the data were homogeneous. If variances were homogeneous, a parametric one-way analysis of variance (ANOVA) and, if necessary, Student-Newman-Keuls' test, was used to determine if significant differences exist between reference organisms and organisms exposed to dredged material. If variances were not homogeneous as judged by Cochran's test, the data were transformed (natural logarithm of x + 1), and the transformed data were evaluated for homogeneity of variances by Cochran's technique. Transformed data exhibiting homogeneous variances were analyzed for significant differences by a parametric one-way ANOVA and, if appropriate, Student-Newman-Keuls' test. When transformed data were characterized by heteroscedasticity, a nonparametric one-way ANOVA (Kruskal and Wallis' test; Sokol and Rohlf, 1969) and, if necessary, Wilcoxon-Mann-Whitneys' STP test were employed to interpret original data. In all statistical tests, the symbols "*" and "ns" are used to denote significant and nonsignificant differences, respectively, at the 95% confidence level (0.05 probability level).

For bulk, elutriate, and EP Toxicity analysis of the sediments, a homogenized subsample was removed and split into aliquots for each analysis. Samples were prepared according to methods of the U.S. EPA and U.S. Army Corps of Engineers

(1977). Grain size distribution analyses were performed in accordance with procedures of ASTM (1972, 1978). Samples for trace metal bulk analyses were digested and analyzed by atomic absorption spectrophotometry (U.S. EPA, 1979, 1984). Analyses for oil and grease were also performed according to methods outlined by the U.S. EPA (1979). Samples for PCB and pesticide analyses were extracted and analyzed by gas chromotography according to methods of the U.S. EPA (1977, 1984).

Benthic taxonomic analysis was performed by hand sorting and microscopic examination of all material retained in the sieve. For each sample of collected material (each sample represents the retained material from one liter of sediment), the number of species and individuals was determined.

3. RESULTS

Results of the solid-phase bioassays, bioaccumulation studies, and all physical, chemical, and taxonomic analyses of dredged material are presented in this section of the report.

3.1 Solid Phase Bioassays

Data produced by solid phase bioassays with grass shrimp, hard clams, and sandworms are summarized in Table 2. Mean survival of organisms exposed for 10 days to dredged material ranged from 80-92% (grass shrimp), 98-100% (hard clams), and 88-95% (sandworms). All raw data from solid phase bioassays appear in Appendix B (Tables B1-B3).

Analysis of survival data for the three species exposed for 10 days to reference sediment and the solid phase of dredged material is presented in Table 3. These data indicate that survival of organisms exposed to the solid phase of dredged material was not significantly less (0.05 probability level) than survival of organisms exposed to reference sediment. Thus, it is concluded that, with regard to its toxicological effects, the solid phase of the dredged material is ecologically acceptable for oceanic discharge.[1]

---

[1] Paragraph 37, page F17, Appendix F of the EPA and COE manual for dredged material (U.S. EPA and U.S. Army COE, 1977) states that a solid phase has "real potential for causing environmentally unacceptable impacts on benthic organisms [only if] difference in mean survival between animals in the control [reference] and test sediments is statistically significant and greater than 10 percent."

Table 2. Survival of grass shrimp (Palaemonetes pugio), hard clams (Mercenaria mercenaria), and sandworms (Nereis virens) exposed for 10 days to the solid phase of dredged material, control sediment, and reference sediment

Organism	Replicate	Number of survivors[a]				
		Control	Reference Sediment	Dredged Material Sample DIS	Dredged Material Sample DIN	Dredged Material Sample NI
Grass shrimp	1	20	17	16	17	16
	2	17	18	18	20	19
	3	20	20	17	16	17
	4	17	13	19	7	20
	5	18	18	14	20	20
	Mean	18.4	17.2	16.8	16.0	18.4
	Percent survival	92.0	86.0	84.0	80.0	92.0
Hard clams	1	20	20	20	20	20
	2	20	20	20	20	20
	3	20	20	19	20	19
	4	20	20	20	20	20
	5	19	20	19	20	20
	Mean	19.8	20.0	19.6	20.0	19.8
	Percent survival	99.0	100.0	98.0	100.0	99.0
Sandworms	1	17	20	20	20	19
	2	20	20	19	19	17
	3	18	19	17	20	17
	4	20	17	15	17	20
	5	20	18	17	19	19
	Mean	19.0	18.8	17.6	19.0	18.4
	Percent survival	95.0	94.0	88.0	95.0	92.0

[a] Data sets in which mean survival of organisms exposed to dredged material is less than survival of reference organisms are enclosed by boxes. Statistical analyses of the enclosed data sets appear in Table 3.

Table 3. Statistical analyses of survival of grass shrimp (*Palaemonetes pugio*), hard clams (*Mercenaria mercenaria*), and sandworms (*Nereis virens*) exposed for 10 days to the solid phase of dredged material and reference sediment

	Cochran's test for homogeneity of variances of survival data				Parametric one-way analysis of variance (ANOVA) of survival data	Nonparametric one-way analysis of variance (ANOVA) of survival data (Kruskal and Wallis' test)
Organism	Treatment	Mean	Variance	$C_{(cal)}$[a]	$F_{(cal)}$[b]	$\chi^2(cal)$[c]
Grass shrimp	Reference sediment	17.2	6.7			
	Dredged material DIS	16.8	3.7	0.67 *		2.26 ns
	Dredged material DIN	16.0	28.5			
	Dredged material NI	18.4	3.3			
Hard clams	Reference sediment	20.0	0.0	0.60 ns	1.47 ns	
	Dredged material DIS	19.6	0.3			
	Dredged material DIN	20.0	0.0			
	Dredged material NI	19.8	0.2			
Sandworms	Reference sediment	18.8	1.7			
	Dredged material DIS	17.6	3.8	0.43 ns	0.87 ns	
	Dredged material DIN	19.0	1.5			
	Dredged material NI	18.4	1.8			

[a] The value for $C_{(cal)}$ is compared to C(tab), which equals 0.63 for 0.5 probability level, $k = 4$, and $v = 4$. Variances are considered to be homogeneous (ns) if $C_{(cal)} \leq C(tab)$. Otherwise, variances are considered to be heterogeneous (*).

[b] The value for $F_{(cal)}$ is compared to F(tab), which equals 3.24 for 0.05 probability level, numerator df = 3, and denominator df = 16. Mean survivals are considered to be nonsignificantly different (ns) if $F_{(cal)} \leq F(tab)$. Otherwise, the difference is considered to be significant (*).

[c] The value for $\chi^2(cal)$ is compared to $\chi^2(tab)$, which equals 7.81 for 0.05 probability level, df = 3. Mean survivals are considered to be nonsignificantly different (ns) if $\chi^2(cal) \leq \chi^2(tab)$. Otherwise, the difference is considered to be significant (*).

3.2 Bioaccumulation Studies

Concentrations of mercury, cadmium, PCBs, DDT, and aromatic hydrocarbons in organisms exposed to control sediment, reference sediment, and the solid phase of dredged material are presented in Tables 4, 5, and 6. Statistical analysis of data sets in which tissue concentrations in organisms exposed to dredged material are greater than concentrations in tissues of reference organisms appears in Table 7. In all cases, concentrations of mercury, cadmium, PCBs, DDT, and aromatic hydrocarbons in organisms exposed to the solid phase of dredged material are not significantly higher (0.05 probability level) than concentrations in reference organisms.

3.3 Physical, Chemical, and Taxonomic Evaluation of Sediment

Results of all physical, chemical, and taxonomic analyses are presented in this section of the report. Results of bulk analysis of sediment samples appear in Table 8; results of analysis of seawater and elutriates formulated from sediment and seawater appear in Table 9; results of EP Toxicity analyses appear in Table 10 and a list of organisms present in sediment from four stations at Deer Island and Nut Island appears in Table 11.

Table 4. Concentration of mercury (Hg), cadmium (Cd), PCBs, DDT, and aromatic hydrocarbons in tissues of grass shrimp (*Palaemonetes pugio*) that survived 10-day exposure to the solid phase of dredged material, control sediment, and reference sediment

Chemical	Replicate	Control	Reference Sediment	Dredged Material Sample DIS	Dredged Material Sample DIN	Dredged Material Sample NI
		Concentration of chemical constituent in tissues (μg/g, wet weight)[a]				
Mercury	1	0.022	0.022	<0.026	0.027	0.021
	2	0.024	0.024	0.040	<0.026	0.017
	3	0.025	0.026	0.030	<0.040	<0.019
	4	<0.033	0.022	0.022	<0.069	<0.027
	5	0.027	<0.020	0.028	<0.027	0.016
	Mean	0.026	0.023	0.029	0.038	0.020
Cadmium	1	0.16	0.030	0.019	0.046	0.037
	2	0.055	0.071	0.022	0.024	<0.007
	3	0.15	0.056	0.045	0.016	<0.015
	4	0.064	0.025	0.040	0.012	0.022
	5	0.066	0.035	0.031	0.014	0.037
	Mean	0.099	0.043	0.031	0.022	0.024
PCBs	1	<0.01	<0.01	<0.01	<0.01	<0.01
	2	<0.01	<0.01	<0.01	<0.01	<0.01
	3	<0.01	<0.01	<0.01	<0.01	<0.01
	4	<0.01	<0.01	<0.01	<0.01	<0.01
	5	<0.01	<0.01	<0.01	<0.01	<0.01
	Mean	<0.01	<0.01	<0.01	<0.01	<0.01
DDT	1	<0.01	<0.01	<0.01	<0.01	<0.01
	2	<0.01	<0.01	<0.01	<0.01	<0.01
	3	<0.01	<0.01	<0.01	<0.01	<0.01
	4	<0.01	<0.01	<0.01	<0.01	<0.01
	5	<0.01	<0.01	<0.01	<0.01	<0.01
	Mean	<0.01	<0.01	<0.01	<0.01	<0.01
Aromatic hydrocarbons	1	<0.10	<0.10	<0.10	<0.10	<0.10
	2	<0.10	<0.10	0.90	<0.10	<0.10
	3	<0.10	<0.10	1.0	<0.10	<0.10
	4	<0.10	<0.10	9.1	<0.10	<0.10
	5	<0.10	<0.10	<0.10	<0.10	<0.10
	Mean	<0.10	<0.10	2.24	<0.10	<0.10

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[a] Data sets in which mean tissue concentration in organisms exposed to dredged material is higher than mean concentration in reference organisms are enclosed by boxes. Statistical analyses of the enclosed data sets appear in Table 7.

Table 5. Concentrations of mercury (Hg), cadmium (Cd), PCBs, DDT, and aromatic hydrocarbons in tissues of hard clams (*Mercenaria mercenaria*) that survived 10-day exposure to the solid phase of dredged material, control sediment, and reference sediment

		Concentration of chemical constituent in tissues (µg/g, wet weight)[a]				
Chemical	Replicate	Control	Reference Sediment	Dredged Material Sample DIS	Dredged Material Sample DIN	Dredged Material Sample NI
Mercury	1	0.015	0.012	0.018	0.010	0.010
	2	0.018	0.012	0.012	0.015	0.011
	3	0.017	0.026	0.011	0.013	0.012
	4	0.019	0.013	0.016	0.010	0.020
	5	0.012	0.016	0.013	0.013	0.024
	Mean	0.016	0.016	0.014	0.012	0.015
Cadmium	1	0.17	0.088	0.051	0.079	0.10
	2	0.050	0.10	0.13	0.11	0.14
	3	0.24	0.096	0.11	0.12	0.093
	4	0.091	0.068	0.092	0.15	0.058
	5	0.16	0.093	0.15	0.13	0.089
	Mean	0.14	0.071	0.107	0.118	0.096
PCBs	1	<0.01	<0.01	<0.01	<0.01	<0.01
	2	<0.01	<0.01	<0.01	<0.01	<0.01
	3	<0.01	<0.01	<0.01	<0.01	<0.01
	4	<0.01	<0.01	<0.01	<0.01	<0.01
	5	<0.01	<0.01	<0.01	<0.01	<0.01
	Mean	<0.01	<0.01	<0.01	<0.01	<0.01
DDT	1	<0.01	<0.01	<0.01	<0.01	<0.01
	2	<0.01	<0.01	<0.01	<0.01	<0.01
	3	<0.01	<0.01	<0.01	<0.01	<0.01
	4	<0.01	<0.01	<0.01	<0.01	<0.01
	5	<0.01	<0.01	<0.01	<0.01	<0.01
	Mean	<0.01	<0.01	<0.01	<0.01	<0.01
Aromatic hydrocarbons	1	<0.10	<0.10	0.30	<0.10	<0.10
	2	<0.10	<0.10	1.0	<0.10	0.30
	3	<0.10	<0.10	0.10	<0.10	0.20
	4	<0.10	<0.10	0.10	<0.10	0.10
	5	<0.10	<0.10	0.30	<0.10	0.10
	Mean	<0.10	<0.10	0.36	<0.10	0.16

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[a] Data sets in which mean tissue concentration in organisms exposed to dredged material is higher than mean concentration in reference organisms are enclosed by boxes. Statistical analyses of the enclosed data sets appear in Table 7.

Table 6. Concentrations of mercury (Hg), cadmium (Cd), PCBs, DDT and aromatic hydrocarbons in tissues of sandworms (Nereis virens) that survived 10-day exposure to the solid phase of dredged material, control sediment, and reference sediment

		Concentration of chemical constituent in tissues (μg/g, wet weight)[a]				
Chemical	Replicate	Control	Reference Sediment	Dredged Material Sample DIS	Dredged Material Sample DIN	Dredged Material Sample NI
Mercury	1	0.006	0.006	0.006	0.009	<0.005
	2	0.006	0.005	0.007	0.005	0.008
	3	<0.005	0.007	<0.005	<0.004	<0.004
	4	0.008	<0.005	0.006	<0.005	0.006
	5	<0.004	<0.005	<0.004	0.009	<0.005
	Mean	0.006	0.0056	0.0056	0.0064	0.0056
Cadmium	1	0.093	0.096	0.11	0.089	0.095
	2	0.10	0.13	0.071	0.090	0.074
	3	0.12	0.11	0.13	0.11	0.072
	4	0.12	0.10	0.083	0.093	0.079
	5	0.11	0.088	0.14	0.082	0.16
	Mean	0.11	0.105	0.107	0.093	0.096
PCBs	1	<0.01	<0.01	<0.01	<0.01	<0.01
	2	<0.01	<0.01	0.04	<0.01	<0.01
	3	0.10	0.06	<0.01	<0.01	<0.01
	4	<0.01	0.04	<0.01	0.04	<0.01
	5	<0.01	<0.01	<0.01	0.02	<0.01
	Mean	0.01	0.026	0.016	0.018	<0.01
DDT	1	<0.01	<0.01	<0.01	<0.01	<0.01
	2	<0.01	<0.01	<0.01	<0.01	<0.01
	3	<0.01	<0.01	<0.01	<0.01	<0.01
	4	<0.01	<0.01	<0.01	<0.01	<0.01
	5	<0.01	<0.01	<0.01	<0.01	<0.01
	Mean	<0.01	<0.01	<0.01	<0.01	<0.01
Aromatic hydrocarbons	1	0.70	0.30	2.0	2.5	0.80
	2	0.70	2.40	0.3	4.9	1.9
	3	0.40	0.20	0.3	2.8	1.2
	4	1.10	0.40	1.0	1.2	2.3
	5	0.40	1.40	0.3	1.4	2.1
	Mean	0.66	0.94	0.78	2.56	1.66

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[a] Data sets in which mean tissue concentration in organisms exposed to dredged material is higher than mean concentration in reference organisms are enclosed by boxes. Statistical analyses of the enclosed data sets appear in Table 7.

Table 7. Statistical analyses of selected data in bioaccumulation study -- data sets in which mean tissue concentration in organisms exposed to dredged material is higher than mean concentration in reference organisms

		Cochran's test for homogeneity of variances of chemical data				Parametric one-way analysis of variance (ANOVA) of chemical data	Student-Newman-Keuls' multiple range test		Nonparametric one-way analysis of variance (ANOVA) of chemical data (Kruskal and Wallis' test)	Wilcoxon-Mann-Whitney's STP test for identifying cause of significant differences in chemical data
Organism	Chemical constituent	Treatment	Mean	Variance	$C_{(cal)}$[a]	$F_{(cal)}$[b]	Difference from control mean[c]	LSD	$\chi^2{}_{(cal)}$[d]	$U_{(cal)}$[e]
Grass shrimp	Mercury	Reference Sediment	0.023	0.000005	0.83*				11.8*	21.5 ns
		Dredged Material Sample DIS	0.029	0.000045						24.5 ns
		Dredged Material Sample DIN	0.038	0.000377						6.0 ns
		Dredged Material Sample NI	0.020	0.000019						
Grass shrimp	Aromatic hydrocarbons	Reference Sediment	<0.10	0.0	1.0*				4.86 ns	
		Dredged Material Sample DIS	2.24	14.9						
		Dredged Material Sample DIN	<0.10	0.0						
		Dredged Material Sample NI	<0.10	0.0						
Hard clams	Cadmium	Reference Sediment	0.071	0.00128	0.34 ns	1.87 ns				
		Dredged Material Sample DIS	0.107	0.00144						
		Dredged Material Sample DIN	0.118	0.00069						
		Dredged Material Sample NI	0.096	0.00086						
Hard clams	Aromatic hydrocarbons	Reference Sediment	<0.10	0.00						
		Dredged Material Sample DIS	0.36	0.138	0.95*				5.14 ns	
		Dredged Material Sample DIN	<0.10	0.00						
		Dredged Material Sample NI	0.16	0.008						

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[a] The value for $C_{(cal)}$ is compared to C(tab), which equals 0.63 for 0.05 probability level, k = 4, and v = 4. Variances are considered to be homogeneous (ns) if $C_{(cal)} \leq C(tab)$. Otherwise, variances are considered to be heterogeneous (*).

[b] The value for $F_{(cal)}$ is compared to F(tab), which equals 3.24 for 0.05 probability level, numerator df = 3, and denominator df = 16. Mean tissue concentrations are considered to be nonsignificantly different (ns) if $F_{(cal)} \leq F(tab)$. Otherwise, the difference is considered to be significant (*).

[c] The difference between the treatment and control means (if treatment mean is larger than control mean) is compared to the least significant difference (LSD), which equals the tabulated significant difference (0.05 probability level) times the square root of the error mean square (calculated during the analysis of variance computation) divided by the number of replicates. Mean tissue concentrations are considered to be nonsignificantly different (ns) if the difference $\leq$ LSD. Otherwise, the difference is considered to be significant.

[d] The value for $\chi^2{}_{(cal)}$ is compared to $\chi^2(tab)$, which equals 7.81 for 0.05 probability level, df = 3. Mean tissue concentrations are considered to be nonsignificantly different (ns) if $\chi^2(cal) \leq \chi^2(tab)$. Otherwise, the difference is considered to be significant (*).

[e] The value for $U_{(cal)}$ is compared to $U_{(tab)}$, which equals 24.5 for 0.05 probability level, t = 4 and r = ∞. Mean tissue concentrations are considered to be nonsignificantly different (ns) if $U_{cal} \leq U(tab)$. Otherwise, the difference is considered to be significant.

Table 7. (Cont.)

		Cochran's test for homogeneity of variances of chemical data				Parametric one-way analysis of variance (ANOVA) of chemical data	Student-Newman-Keuls' multiple range test		Nonparametric one-way analysis of variance (ANOVA) of chemical data (Kruskal and Wallis' test)	Wilcoxon-Mann-Whitney's STP test for identifying cause of significant differences in chemical data
Organism	Chemical constituent	Treatment	Mean	Variance	$C_{(cal)}$[a]	$F_{(cal)}$[b]	Difference from control mean[c]	LSD	$\chi^2_{(cal)}$[d]	$U_{(cal)}$[e]
Sand-worms	Mercury	Reference Sediment	0.0056	0.0000008	0.57 ns	0.31 ns				
		Dredged Material Sample DIS	0.0056	0.0000013						
		Dredged Material Sample DIN	0.0064	0.0000058						
		Dredged Material Sample NI	0.0056	0.0000023						
Sand-worms	Cadmium	Reference Sediment	0.105	0.00026	0.52 ns	0.35 ns				
		Dredged Material Sample DIS	0.107	0.00087						
		Dredged Material Sample DIN	0.093	0.00011						
		Dredged Material Sample NI	0.096	0.00136						
Sand-worms	Aromatic hydrocarbons	Reference Sediment	0.94	0.898	0.54 ns	3.27*				
		Dredged Material Sample DIS	0.78	0.557						
		Dredged Material Sample DIN	2.56	2.183			1.62	1.64 ns		
		Dredged Material Sample NI	1.66	0.403			0.72	1.35 ns		

Table 8. Results of bulk analysis of sediment from Deer Island and Nut Island

	Type of Analysis (unit of measurement)									
Sample	Arsenic (µg/g, dry wt.)	Cadmium (µg/g, dry wt.)	Chromium (µg/g, dry wt.)	Copper (µg/g, dry wt.)	Lead (µg/g, dry wt.)	Mercury (µg/g, dry wt.)	Nickel (µg/g, dry wt.)	Zinc (µg/g, dry wt.)	PCBs (µg/g, dry wt.)	Chloride (µg/g, dry wt.)
Composite of DIN-1, DIN-2, and DIN-3	4.1	0.81	78	44	560	0.44	15	93	0.07	8,290
Composite of DIN-4, DIN-5, and DIN-6	3.8	<0.30	34	15	15	0.10	13	46	0.02	8,390
Composite of DIN-7 and DIN-8	3.8	<0.26	28	12	10	0.057	11	39	0.05	7,000
Composite of DIN-9 and DIN-10	3.7	0.44	44	26	35	0.10	11	31	0.09	6,600
Composite of DIN-4 (surface), DIN-5 (surface), and DIN-6 (surface)	4.3	0.33	40	19	20	0.11	13	56	0.10	10,600
DIS-1	4.4	<0.32	38	17	16	0.11	13	50	0.01	7,320
DIS-2	4.6	0.55	68	38	50	0.41	12	82	0.02	6,870
DIS-3	5.7	1.0	115	56	74	0.37	16	130	0.12	9,160
DIS-4	4.2	1.1	99	48	38	0.30	14	93	0.22	7,610
DIS-5	3.2	0.89	86	43	51	0.33	12	95	0.02	6,860
DIS-6	4.6	2.4	190	92	76	0.56	19	170	0.33	9,370
DIS-1 (Surface)	5.1	0.79	110	65	56	0.41	13	85	0.16	7,710
DIS-5 (Surface)	5.7	2.5	230	150	110	0.74	24	220	0.13	12,300
NI-1	8.6	0.33	26	210	840	0.25	18	210	0.11	6,290
NI-2	4.1	0.34	24	11	8.5	0.020	14	43	<0.01	6,730
NI-3	4.4	0.32	28	15	15	0.097	15	170	0.01	7,240
NI-4	4.6	0.60	57	50	93	0.67	15	130	0.14	8,960
NI-5	4.7	0.37	32	14	13	0.032	16	48	0.05	9,950
NI-6	4.0	0.40	34	16	15	0.072	15	230	0.01	8,110
NI-2 (Surface)	2.0	0.43	28	26	34	0.20	13	60	0.05	7,180
NI-4 (Surface)	3.2	0.55	60	46	62	0.38	12	90	0.07	6,080

Table 8. (Cont.)

Sample	Oil & Grease (µg/g, dry wt.)	Volatile Solids (%)	Water (%)	Specific Gravity (g samples/ g water)	Grain Size Distribution (wt. %)			
					Gravel (>1 mm)	Sand (1.0- 0.0625 mm)	Silt (0.0625- 0.0039 mm)	Clay (<0.0039 mm)
Composite of DIN-1, DIN-2, and DIN-3	541	5.26	37.2	1.49	14	38	29	19
Composite of DIN-4, DIN-5, and DIN-6	144	5.33	37.9	1.52	0	27	53	20
Composite of DIN-7 and DIN-8	272	3.41	33.4	1.60	0	38	45	17
Composite of DIN-9 and DIN-10	400	3.45	33.5	1.59	0	23	54	23
Composite of DIN-4 (surface), DIN-5 (surface), and DIN-6 (surface)	600	4.12	38.8	1.49	3	69	15	13
DIS-1	<35.2	2.78	32.4	1.59	12	59	21	8
DIS-2	156	5.26	34.8	1.55	3	22	53	22
DIS-3	565	13.1	43.0	1.56	0	50	31	19
DIS-4	262	5.41	35.6	1.49	1	45	41	13
DIS-5	105	4.87	30.6	1.52	0	63	25	12
DIS-6	811	5.42	42.4	1.45	0	53	30	17
DIS-1 (Surface)	588	3.68	38.5	1.52	2	71	18	9
DIS-5 (Surface)	1,180	8.36	51.4	1.34	3	33	46	18
NI-1	34.1	8.54	30.3	1.68	0	60	30	10
NI-2	<42.2	3.80	32.9	1.62	3	55	33	9
NI-3	289	5.06	34.3	1.54	4	44	38	14
NI-4	564	5.25	39.6	1.48	2	35	46	17
NI-5	42.6	6.37	39.8	1.50	5	30	46	19
NI-6	<34.4	4.40	39.7	1.51	1	33	47	19
NI-2 (Surface)	263	1.67	28.0	1.68	0	87	8	5
NI-4 (Surface)	63.1	4.26	34.0	1.63	0	76	12	12

Table 9. Results of analyses of seawater and sediment elutriates from Deer Island and Nut Island

		Type of analysis (unit of measurement)									
Sample	Replicate	Arsenic (μg/l)	Cadmium (μg/l)	Chromium (μg/l)	Copper (μg/l)	Lead (μg/l)	Mercury (μg/l)	Nickel (μg/l)	Zinc (μg/l)	PCBs (μg/l)	Oil & Grease (μg/l)
DIS Seawater	1	1.2	<0.5	<10	1.6	<2	<0.4	<1	9.3	<0.10	1.0
	2	1.2	<0.5	<10	1.6	<2	<0.4	<1	9.0	<0.10	
	3	1.1	<0.5	<10	1.6	<2	<0.4	<1	9.4	<0.10	
DIN Seawater	1	1.2	0.6	<10	2.5	<2	<0.4	<1	27	<0.10	1.0
	2	1.2	0.6	<10	2.8	<2	<0.4	<1	27	<0.10	
	3	1.1	0.6	<10	2.8	<2	<0.4	<1	26	<0.10	
NI Seawater	1	1.2	<0.5	<10	2.0	<2	<0.4	<1	19	<0.10	<1.0
	2	1.2	<0.5	<10	2.0	<2	<0.4	<1	19	<0.10	
	3	1.2	<0.5	<10	2.0	<2	<0.4	<1	19	<0.10	
Composite of DIN-1, DIN-2, DIN-3, DIN-4, DIN-5, DIN-6, DIN-7, DIN-8, DIN-9, DIN-10 elutriate	1	6.0	<0.5	<10	<1	<2	<0.4	120	87	<0.10	<1.0
	2	5.8	<0.5	<10	<1	<2	<0.4	120	84	<0.10	
	3	5.3	<0.5	<10	<1	<2	<0.4	120	85	<0.10	
DIS 1 Elutriate	1	11	<0.5	<10	<1	<2	<0.4	32	31	<0.10	10.0
	2	11	<0.5	<10	<1	<2	<0.4	33	32	<0.10	
	3	10	<0.5	<10	<1	<2	<0.4	32	32	<0.10	
Composite of DIS-5 and DIS-6 elutriate	1	1.5	<0.5	<10	2.1	<2	<0.4	10	49	<0.10	2.8
	2	1.5	<0.5	<10	2.1	<2	<0.4	10	50	<0.10	
	3	1.6	<0.5	<10	2.1	<2	<0.4	11	49	<0.10	
Composite of NI-1 and NI-3 elutriate	1	2.3	<0.5	<10	2.2	3.2	<0.4	22	67	<0.10	<1.0
	2	2.2	<0.5	<10	2.1	3.3	<0.4	22	68	<0.10	
	3	2.1	<0.5	<10	2.1	3.3	<0.4	22	67	<0.10	
Composite of NI-4 and NI-6 elutriate	1	2.1	<0.5	<10	<1	<2	<0.4	22	126	<0.10	<1.0
	2	2.2	<0.5	<10	<1	<2	<0.4	21	127	<0.10	
	3	2.3	<0.5	<10	<1	<2	<0.4	22	120	<0.10	

Table 10. Results of EP Toxicity analysis of sediment from Deer Island and Nut Island

Sample	Type of Analysis (Unit of Measurement)															
	Silver (mg/l)	Arsenic (mg/l)	Barium (mg/l)	Cadmium (mg/l)	Chromium (mg/l)	Mercury (mg/l)	Sodium (mg/l)	Lead (mg/l)	Selenium (mg/l)	Chloride (mg/l)	Lindane (mg/l)	Endrin (mg/l)	Methoyx-chlor (mg/l)	Toxa-phene (mg/l)	Silvex (mg/l)	2-4,D (mg/l)
Composite of DIN-1, DIN-2, DIN-3, DIN-4, DIN-5, DIN-6, DIN-7, DIN-8, DIN-9, DIN-10	<0.020	<0.010	<2.0	<0.020	<0.20	<0.0002	200	<0.20	<0.020	308	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001
DIS-1	<0.020	<0.010	<2.0	<0.020	<0.20	<0.0002	190	<0.20	<0.020	310	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001
DIS-4	<0.020	<0.010	<2.0	<0.020	<0.20	<0.0002	160	<0.20	<0.020	260	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001
Composite of DIS-5 and DIS-6	<0.020	<0.010	<2.0	<0.020	<0.20	<0.0002	190	<0.20	<0.020	298	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001
NI-2	<0.020	<0.010	<2.0	<0.020	<0.20	<0.0002	170	<0.20	<0.020	268	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001
NI-4	<0.020	<0.010	<2.0	<0.020	<0.20	<0.0002	190	<0.20	<0.020	298	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001
NI-6	<0.020	<0.010	<2.0	<0.020	<0.20	<0.0002	180	<0.20	<0.020	298	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001

Table 11. Results of taxonomic analysis of sediment from Deer Island and Nut Island

Species Name	Number of organisms per liter of sediment			
	Station DIN-5	Station DIS-1	Station DIS-6	Station NI-2
Photis macrocoxa	1			
Oligochaeta	13	37		
Streblospio benedicti	3	20		26
Capitella capitata	1			
Polydora ligni	1			
Spio sp.	1			8
Nephtys caeca	1			1
Botryllus schlosseri	b			
Campanularis gelatinuosa	b			b
Nassarius trivitatus	2	2	1	1
Polydora socialis		1		
Diastylis sculpta		1		
Ampelisca abdita		2		1
Mytilidae[a]			12	
Cirratulidae				1
Spio setosa				4
Spiophanes bombyx				1

[a] All *Mytilidae* hinged but without meat.

[b] Present, but in poor condition.

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APPENDIX A

LABORATORY PROCEDURES FOR PREPARING DREDGED MATERIAL AND CONDUCTING BIOASSAYS

Procedure	Date of Implementation of Procedure	Certifications of Performance of Procedures		
		Aquatic Toxicologist	Aquatic Toxicologist	Laboratory Director
1. Store control sediment (CS), reference sediment (RS), and dredged sediment (DS) at 2-4°C in separate containers. Mix sediment in each container as thoroughly as possible.	CS 03/27/86			
	DS 03/25-28/86	"	"	"
	RS 03/18/86	"	"	"

Solid Phase Bioassays

Bioassays should be initiated by April 1, 1986 (2 weeks after March 18, 1986, earliest date of sediment collection). Do not be concerned with sophisticated photoperiod. Maintain dissolved oxygen in aquaria at >4 ppm. Cover aquaria to prevent salinity changes.

2. Remove CS, DS, and RS from storage and wet sieve through 1-mm mesh. Use minimum volume of artificial seawater [ASW] of salinity 30 ppt for sieving purposes. Place nonliving material remaining on sieve in appropriate containers.	03/28	"	"	"
3. Mix CS, DS, and RS and allow to settle for 6 hr.	03/28	"	"	"
4. Decant ASW and mix CS, DS, and RS as thoroughly as possible.	03/28	"	"	"
5. Assign treatments (CS, RS and DS) and replicates (5 r per treatment) to aquaria.	03/28	"	"	"

Procedure	Date of Implementation of Procedure	Certifications of Performance of Procedures		
		Aquatic Toxicologist	Aquatic Toxicologist	Laboratory Director
6. Randomly position aquaria in environmental chamber maintained at 20±1°C.	03/28	"	"	"
7. Place 45 mm of CS in each control aquaria, 45 mm of RS in reference aquaria and 30 mm of RS in treatment aquaria. Add 15 mm DS over RS in treatment aquaria.	03/28	"	"	"
8. Fill aquaria to capacity and allow to settle for 1 hr.	03/28	"	"	"
9. Turn a flow-through system and allow to run for 1 exchange before adding organisms.	03/28	"	"	"
10. Select sandworms from holding tanks and randomly distribute 20 into each culture dish. Follow same procedure for hard clams.	03/28	"	"	"
11. Randomly distribute contents of culture dishes into aquaria on the incoming water side.	03/28	"	"	"
12. If necessary, replace any animals that do not burrow in a reasonable time (10 min for worms, 30 min for clams).	03/28	"	"	"

Procedure	Date of Implementation of Procedure	Certifications of Performance of Procedures		
		Aquatic Toxicologist	Aquatic Toxicologist	Laboratory Director
13. Select grass shrimp from holding tank and randomly distribute 20 into each culture dish.	03/28	"	"	"
14. Randomly distribute contents of culture dishes into aquaria. Add a few glass vials.	03/28	"	"	"
15. Perform the following activities:				
Every day after introduction of grass shrimp into aquaria				
• Record temperature, dissolved oxygen, and pH in each aquarium (record in log book).	Day 0 03/28	"	"	"
	Day 1 03/29	"	"	"
	Day 2 03/30	"	"	"
• Record obvious mortality, formation of tubes or burrows, and unusual behavior patterns of animals (record in log book).	Day 3 03/31	"	"	"
	Day 4 04/01	"	"	"
	Day 5 04/02	"	"	"
	Day 6 04/03	"	"	"
	Day 7 04/04	"	"	"
	Day 8 04/05	"	"	"
	Day 9 04/06	"	"	"
	Day 10 04/07	"	"	"
16. At end of 10-day testing period, sieve sediment in each aquarium. Count live animals.	04/07	"	"	"

Procedure	Date of Implementation of Procedure	Certifications of Performance of Procedures		
		Aquatic Toxicologist	Aquatic Toxicologist	Laboratory Director
16. (Continued) Note sublethal responses. Depurate surviving organisms in ASW under flow-through conditions for 48 hr and preserve for bioaccumulation study.				

Table B.1. Results of solid phase bioassays with grass shrimp (*Palaemonetes pugio*), hard clams (*Mercenaria mercenaria*), and sandworms (*Nereis virens*)[a]

Treatment	Replicate	Number of survivors[b,c]		
		Grass Shrimp	Hard Clams	Sandworms
Control Sediment	1	20	20	17
	2	17	20	20
	3	20	20	18
	4	17	20	20
	5	18	19	20
Reference Sediment	1	17	20	20
	2	18	20	20
	3	20	20	19
	4	13	20	17
	5	18	20	18
Dredged Material Sample DIS	1	16	20	20
	2	18	20	19
	3	17	19	17
	4	19	20	15
	5	14	19	17
Dredged Material Sample DIN	1	17	20	20
	2	20	20	19
	3	16	20	20
	4	7	20	17
	5	20	20	19
Dredged Material Sample NI	1	16	20	19
	2	19	20	17
	3	17	19	17
	4	20	20	20
	5	20	20	19

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[a] Bioassays (10-day tests) were conducted at 20±1°C in 38-liter aquaria. Organisms were exposed to each replicate of a treatment in a single aquarium. Water in aquaria was exchanged by the flow-through method and was aerated. A 14-hour light and 10-hr dark photoperiod was maintained with cool-white fluorescent bulbs. Salinity was maintained at 30 ppt.

[b] Twenty (20) individuals of each species were initially exposed to each replicate of a treatment. Thus, a total of 60 animals was employed in each aquarium.

[c] In addition to monitoring survival of all species, burrowing behavior of sandworms was noted each day. No differences were observed among aquaria.

Table B.2. Dissolved oxygen concentrations measured during solid phase bioassays with grass shrimp (*Palaemonetes pugio*), hard clams (*Mercenaria mercenaria*), and sandworms (*Nereis virens*)

		Dissolved oxygen (mg/l)									
Treatment	Replicate	Day 0	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
Control Sediment	1	8.1	7.6	7.3	7.1	7.2	7.7	6.6	7.7	7.6	6.0
	2	7.9	7.5	6.5	7.4	7.3	7.9	6.8	7.8	8.1	6.7
	3	8.4	7.5	6.7	7.5	7.1	7.8	6.8	7.8	7.8	6.1
	4	8.1	7.5	7.2	7.2	7.6	7.8	7.0	7.7	7.4	6.2
	5	8.2	7.5	7.0	7.2	6.8	7.5	7.1	7.5	7.4	7.8
Reference Sediment	1	8.1	7.6	7.0	7.3	7.2	7.2	6.8	7.8	7.6	6.5
	2	7.9	7.6	7.2	7.5	7.5	7.5	7.0	8.0	7.2	6.9
	3	8.0	7.6	6.9	7.4	7.4	7.4	7.1	7.8	7.5	6.9
	4	7.6	7.6	7.1	7.4	7.2	7.5	7.2	7.3	7.2	7.8
	5	7.9	7.6	7.2	7.0	7.6	7.0	6.8	7.9	7.5	6.9
Dredged Material Sample DIS	1	7.4	7.0	7.3	7.5	7.0	8.2	7.4	7.8	7.4	6.8
	2	7.8	7.1	7.2	7.5	7.6	7.8	7.6	7.4	7.4	6.5
	3	7.6	7.5	7.1	7.7	7.3	7.8	7.2	7.6	7.3	7.0
	4	7.8	7.5	7.3	7.1	7.1	8.0	7.4	7.8	7.4	6.5
	5	7.8	7.3	7.0	7.4	7.3	8.1	7.4	7.5	7.4	6.5
Dredged Material Sample DIN	1	7.2	7.4	7.3	7.5	7.7	7.4	7.6	7.6	7.8	7.0
	2	7.8	7.3	7.2	7.5	7.8	7.5	7.6	8.0	7.4	6.8
	3	7.4	7.3	7.2	7.1	7.0	7.2	7.0	7.5	7.4	7.1
	4	7.8	7.3	5.5	5.8	7.3	7.4	7.2	7.8	7.7	7.9
	5	8.3	7.3	6.8	7.2	6.8	7.5	7.4	7.5	7.1	6.7
Dredged Material Sample NI	1	7.8	7.0	7.2	7.1	6.8	7.8	7.4	8.0	6.8	6.8
	2	7.2	7.0	7.1	7.4	6.0	7.8	7.2	7.5	6.5	6.5
	3	7.3	7.0	7.2	7.4	7.6	8.0	7.5	7.8	6.8	7.1
	4	7.9	7.3	7.1	7.2	6.4	7.5	7.4	7.4	6.9	6.7
	5	7.9	7.1	6.7	7.6	7.2	8.0	7.2	8.0	7.2	6.7

Table B.3. pH values measured during solid phase bioassays with grass shrimp (*Palaemonetes pugio*), hard clams (*Mercenaria mercenaria*), and sandworms (*Nereis virens*)

		Dissolved oxygen (mg/l)									
Treatment	Replicate	Day 0	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10
Control Sediment	1	8.0	7.9	7.9	7.8	7.9	7.9	8.0	8.0	7.9	7.8
	2	8.0	8.0	8.0	7.8	8.0	8.0	8.0	8.0	8.0	7.9
	3	8.0	8.0	8.0	7.8	8.0	8.1	8.0	8.1	7.9	7.9
	4	8.0	7.9	8.1	7.9	8.0	8.1	8.0	8.1	8.0	7.8
	5	8.0	7.9	7.9	7.9	7.9	8.1	8.0	8.0	8.1	8.0
Reference Sediment	1	8.0	7.9	8.1	7.9	8.0	8.1	8.0	8.0	8.0	7.9
	2	8.0	8.0	8.0	7.8	7.9	8.0	8.0	8.1	7.8	7.9
	3	8.0	8.0	8.0	7.9	7.9	8.0	7.9	8.0	8.0	7.8
	4	8.0	7.9	7.5	7.9	7.8	7.5	7.7	7.8	7.8	7.8
	5	8.0	8.0	7.9	7.8	7.8	7.9	7.9	8.0	7.9	7.8
Dredged Material Sample DIS	1	8.0	8.0	8.0	7.9	7.8	8.0	7.8	7.9	7.8	7.8
	2	8.0	8.0	7.9	7.9	7.9	7.9	7.9	8.0	8.0	7.9
	3	8.0	8.0	8.0	7.8	7.9	8.0	7.9	7.9	7.9	7.9
	4	8.0	8.0	8.0	7.8	7.9	8.0	7.8	7.9	7.8	7.8
	5	8.0	8.0	8.0	7.8	7.8	8.0	7.7	7.8	7.8	7.9
Dredged Material Sample DIN	1	8.0	8.0	8.0	7.8	7.7	8.0	7.8	7.9	7.9	7.9
	2	8.0	7.9	8.0	7.9	7.9	7.9	7.8	8.0	7.9	7.8
	3	8.0	7.8	8.0	7.9	7.8	7.9	7.9	7.9	7.9	7.9
	4	8.0	7.8	8.0	7.8	7.5	8.0	7.9	7.9	7.9	7.8
	5	8.0	7.9	8.0	7.8	6.8	8.0	7.8	7.9	7.9	7.8
Dredged Material Sample NI	1	8.0	8.1	8.0	7.7	7.8	8.0	7.9	8.0	8.0	8.0
	2	8.0	8.1	7.9	7.8	7.5	7.9	7.8	8.0	7.7	7.7
	3	8.0	8.0	7.9	7.8	7.7	8.0	7.6	7.9	7.4	7.8
	4	8.0	8.0	8.0	7.9	7.9	8.0	7.7	7.9	7.9	7.9
	5	8.0	8.0	7.9	7.9	7.8	8.1	7.9	8.0	7.9	7.8

Appendix C.1. Quality-control information pertaining to bioaccumulation studies

Type of Quality-Control Information (unit of measurement)	Chemical Constituent	Organism Analyzed		
		Grass Shrimp (*Palaemonetes pugio*)	Hard Clams (*Mercenaria mercenaria*)	Sandworms (*Nereis virens*)
1. Pretesting data (concentrations of chemical constituents in organisms prior to testing -- ug/g wet wt.)	Cadmium (Cd)	0.066, 0.19, 0.078	0.48, 0.41, 0.097	0.11, 0.080, 0.095
	Mercury (Hg)	0.027, 0.035, 0.022	0.023, 0.019, 0.012	<0.004, <0.004, <0.004
	PCBs	<0.01, <0.01, <0.01	<0.01, <0.01, <0.01	<0.01, <0.01, <0.01
	DDT	<0.01, <0.01, <0.01	<0.01, <0.01, <0.01	<0.01, <0.01, <0.01
	Aromatic hydrocarbons	0.10, 0.10, <0.10	0.10, <0.10, <0.10	0.20, 0.60, 0.40
2. Precision data (concentrations of chemical constituents in duplicate subsamples of one set of organisms exposed to dredged material -- ug/g wet wt.)	Cadmium (Cd)	0.018, 0.030	0.14, 0.11	0.071, 0.074
	Mercury (Hg)	0.028, 0.032	0.010, 0.013	0.006, 0.005
	PCBs	<0.01, <0.01	<0.01, <0.01	<0.01, <0.01
	DDT	<0.01, <0.01	<0.01, <0.01	<0.01, <0.01
	Aromatic hydrocarbons	<0.10, <0.10	<0.10, <0.10	0.30, 1.40

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ADDITIONAL SEDIMENT SAMPLING PLAN FOR SITE ACCESS FACILITIES CONSTRUCTION AT NUT ISLAND

The construction of new wastewater treatment facilities (headworkd) at Nut Island may require the construction of permanent piers, docks and moorings at Nut Island.

Included herein is a sediment sampling program to be used in the environmental analysis of site access facility options at the northeast end of Nut Island. This sampling program has the same scope and intent as the program conducted in the Spring of 1986 off the east shore of Nut Island.

1. The first task is the collection of bathymetry datal

2. The second task is the chemical/physical characterization of Nut Island sediments. The sampling program is summarized in Table 1. Continuous, undisturbed gravity core samples will be collected to depth (or refusal) at seven locations at Nut Island (Figure 1). Visual descriptions of the sediment horizons will be done for all core samples (these are called "tube logs"). For each core, samples will be extracted from each horizon (with elutriate) and be retained in refrigerated storage for subsequent analysis, as required. Based on the tube logs, the portion of each core lying above virgin marine clay will be composited (one verticle composite per core). Seven vertical composites and three surface (top 6") grab samples will each be tested for bulk sediment chemistry (As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, PCB's, oil and grease).

   These samples will be tested for standard physical parameters (percent volatile solids, percent water, grain-size distribution, specific gravity).

   At Nut Island, four elutriate tests will be done for sediments from NIN-2, NIN-3, NIN-5 and NIN-6.

   This information will be used to address the questions of potential impact at the construction sites. Results of these tests and other recent analyses will be evaluated in the context of published operational limits for sediment classification (Massachusetts Division of Water Pollution Control, 1978, New England River Basins Commission, 1980) and current water quality criteria for the protection of saltwater aquatic life (U.S.EPA, 1976, Federal Register 11/20/80, 8/13/81, 2/15/84 and 314 CMR 4.03).

3. The third task is a bioassay and bioaccumulation tests to assess the impact of dredged material disposal on marine organisms.

   Composited samples will be used for bioassay/bioaccumulation test. Sampling stations selected for bioassay/bioaccumulation composites correspond to the areas where dredging may occur. Each of the cores selected will be vertically composited to the depth of potential dredging or core refusal. Stations to be composited for bioassay/bioaccumulation test are:

   - Nut Island Permanent / Temporary Facility
     NIN-2, NIN_3, NIN-4, NIN-5 and NIN-6.

   These tests will be performed according to methods of the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency (1977), and will be used to compare the characteristics of the material to the characteristics of material from a reference area located outside the boundary of the disposal sites.

4. Under the fourth task, sediments will be tested for the presence of hazardous waste using EPA's EP Toxicity method. Cores will be vertically composited to the depth of potential dredging. Tests will then be made on the following samples:

   - Nut Island Permanent / Temporary Facilities
     - Composite of NIN-2 through NIN-6

   EPA's EP Toxicity test analyzes a sample for the following parameters: As, Ba, Cd, Cr, Pb, Hg, Se, Ag, endrin, lindane, methoxychor, toxaphene, 2,4 D and 2,4,5 TP (silvex). The results of the EP Toxicity tests will be compared with the Resource Conservation and Recovery Acts (RCRA) criteria for hazardous waste. The results will help determine whether or not the sediment is suitable for disposal on land.

   Samples tested for the parameters of EP Toxicity will also be tested for sodium and chloride using the EP Toxicity extraction procedure .

5. The fifth task is the collection of surface grab samples for macrobenthic identification and count. Samples will be collected and seived (0.595 mm screen) at Stations NIN-1, NIN-4 and NIN-7. Macrobenthic organisms will be counted, and identified to species level where possible, and to the genus level otherwise.

APPENDIX A

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NOTES

TABLE 1

(1) Bulk Sediment Physical Analysis:

percent water, percent volatile solids, grain size (seive and hydrometer), specific gravity.

(2) Bulk Sediment Chemical Analysis:

As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, PCB (total), Oil & Grease.

(3) Elutriate and Control (Sea Water) Analysis:

As, Cd, Cr, Cu, Pb, Hg, Ni, Zn, PCB (total), Oil & Grease.

(4) Solid Phase Bioassay:

Grass Shrimp, Hard Clams, Sand Worms

Bioaccumulation:

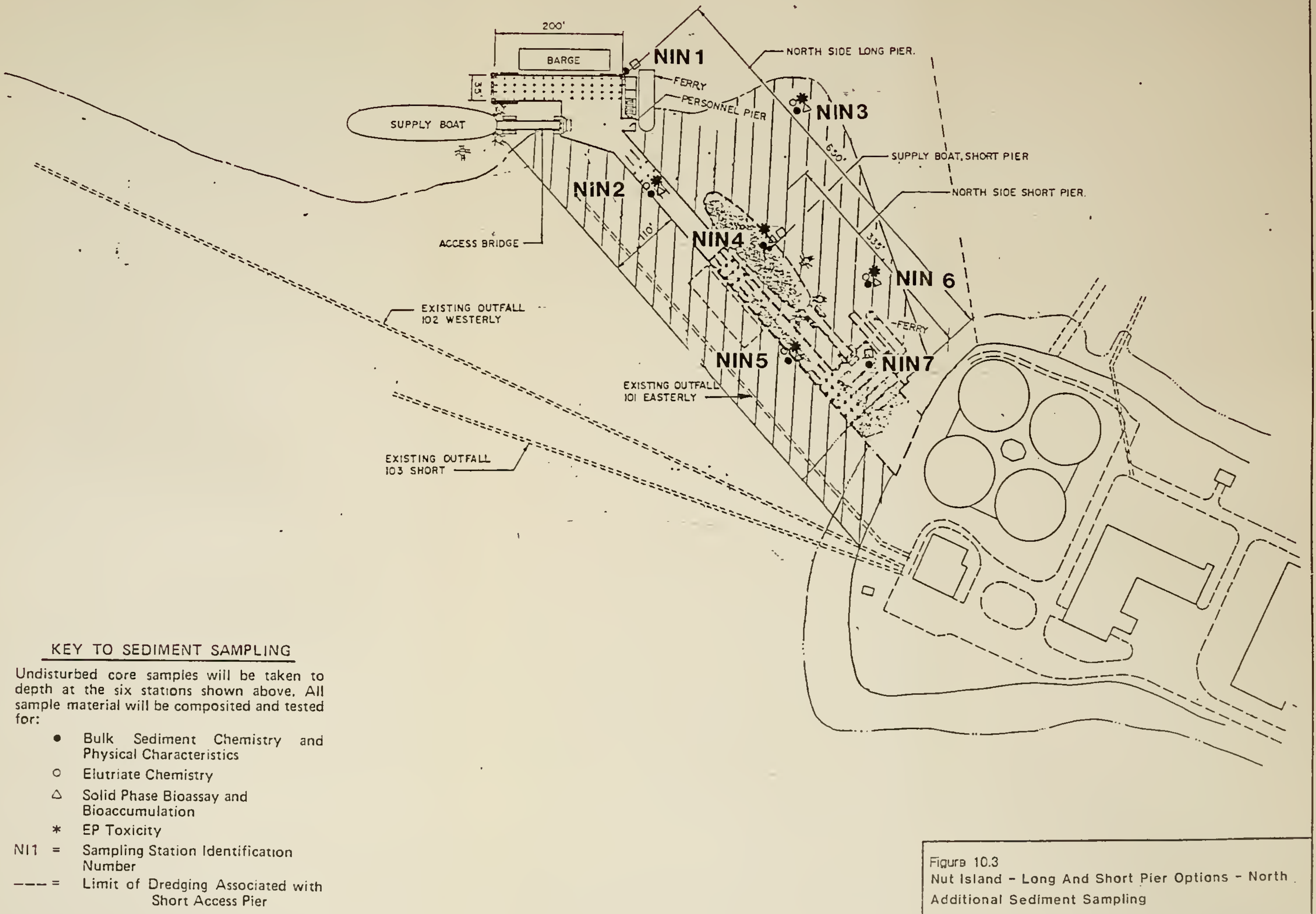
(same organisms as bioassay) testing for Cd, Hg, PCBs, DDT family and aromatic hydrocarbons.

(5) EPA EP Toxicity:

As, Ba, Cd, Cr, Pb, Hg, Se, Ag, endrin, lindane, methoxychor, toxaphene, 2,4 D and 2,4,5 TP (Silvex).

TABLE 1
ADDITIONAL SEDIMENT SAMPLING PROGRAM
NUT ISLAND

Parameter	Permanent / Temporary Facilities
1. Number of Sample Locations	7 (NIN-1 to NIN-7)
2. Sample Type	Continuous Undisturbed Core to Project Depth (or refusal) (NIN-1 to NIN-7)
3. Core Description	Tube Log with Sediment horizons for all Cores (NIN-1 to NIN-7)
4. Bulk Sediment Analysis A. Physical (See Note 1) B. Chemical (See Note 2)	10 Analyses: . 1 for Each Core, Consisting of Vertical Composite of Core Lying Above Virgin Marine Clay (NIN-1 to NIN-7), and . three surface grab samples from NIN-1, NIN-4 and NIN-7
5. Elutriate Analysis (See Note 3)	4 Elutriate Analyses: Composites from: . NIN-2, NIN-3 . NIN-5 and NIN-6 (using vertical composite of core above virgin marine clay)
6. Bioassay/Bioaccumulation (See Note 4)	1 Analysis: Composite from All Seven Cores (each core vertically composited to depth of potential dredging)
7. EP Toxicty, Na, Cl^- (See Note 5)	1 Analysis: . Composite of NIN-2, NIN-3, NIN-5 and NIN-6 (each core vertically composited to depth of potential dredging)
8. Macrobenthic Identification	Analysis of grab samples and Count from NIN-1, NIN-4, and NIN-7



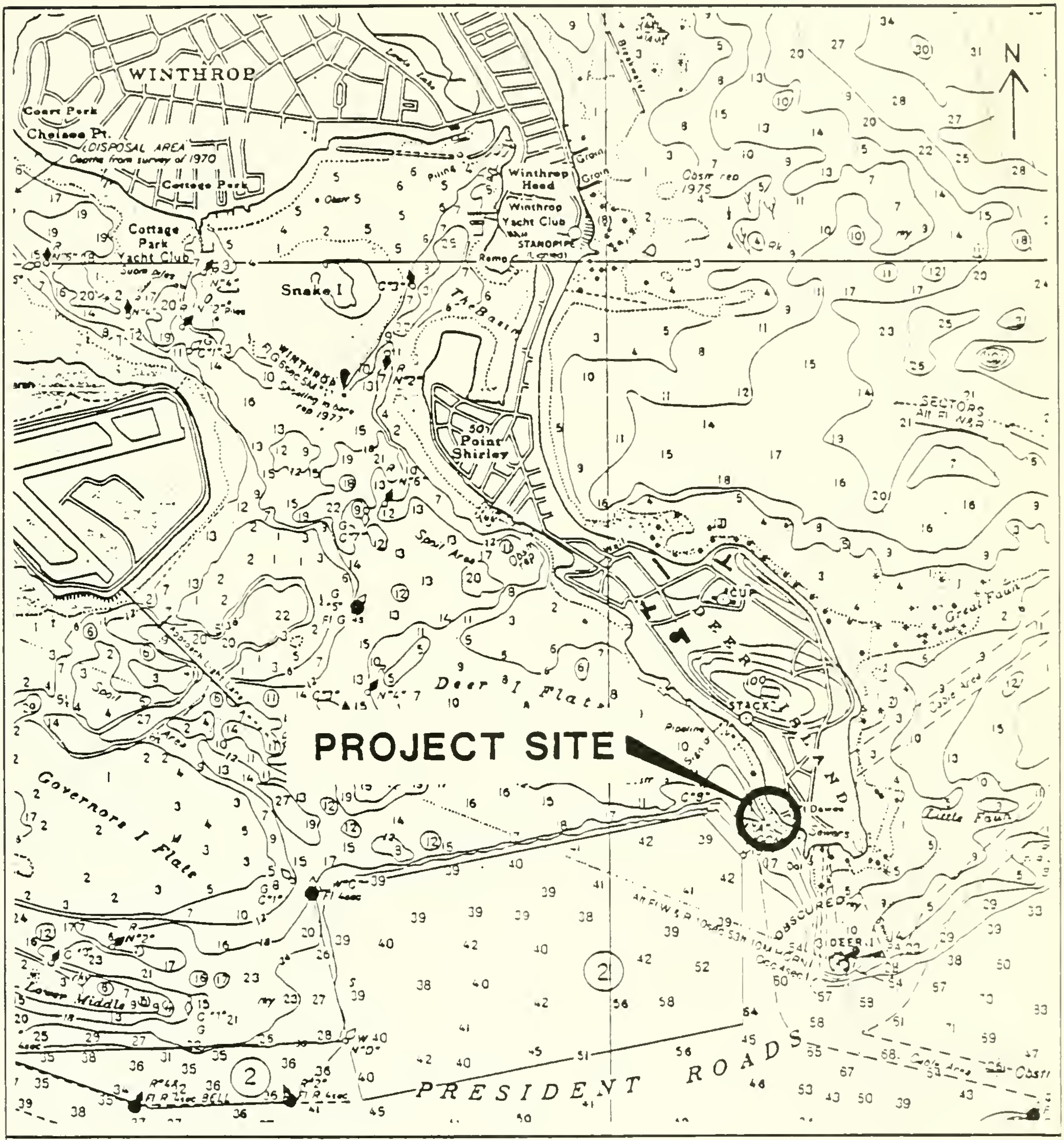
KEY TO SEDIMENT SAMPLING

Undisturbed core samples will be taken to depth at the six stations shown above. All sample material will be composited and tested for:

●	Bulk Sediment Chemistry and Physical Characteristics
○	Elutriate Chemistry
△	Solid Phase Bioassay and Bioaccumulation
*	EP Toxicity
NI1 =	Sampling Station Identification Number
--- =	Limit of Dredging Associated with Short Access Pier

Figure 10.3
Nut Island - Long And Short Pier Options - North
Additional Sediment Sampling

MWRA
On-Island Water Transportation Facilities



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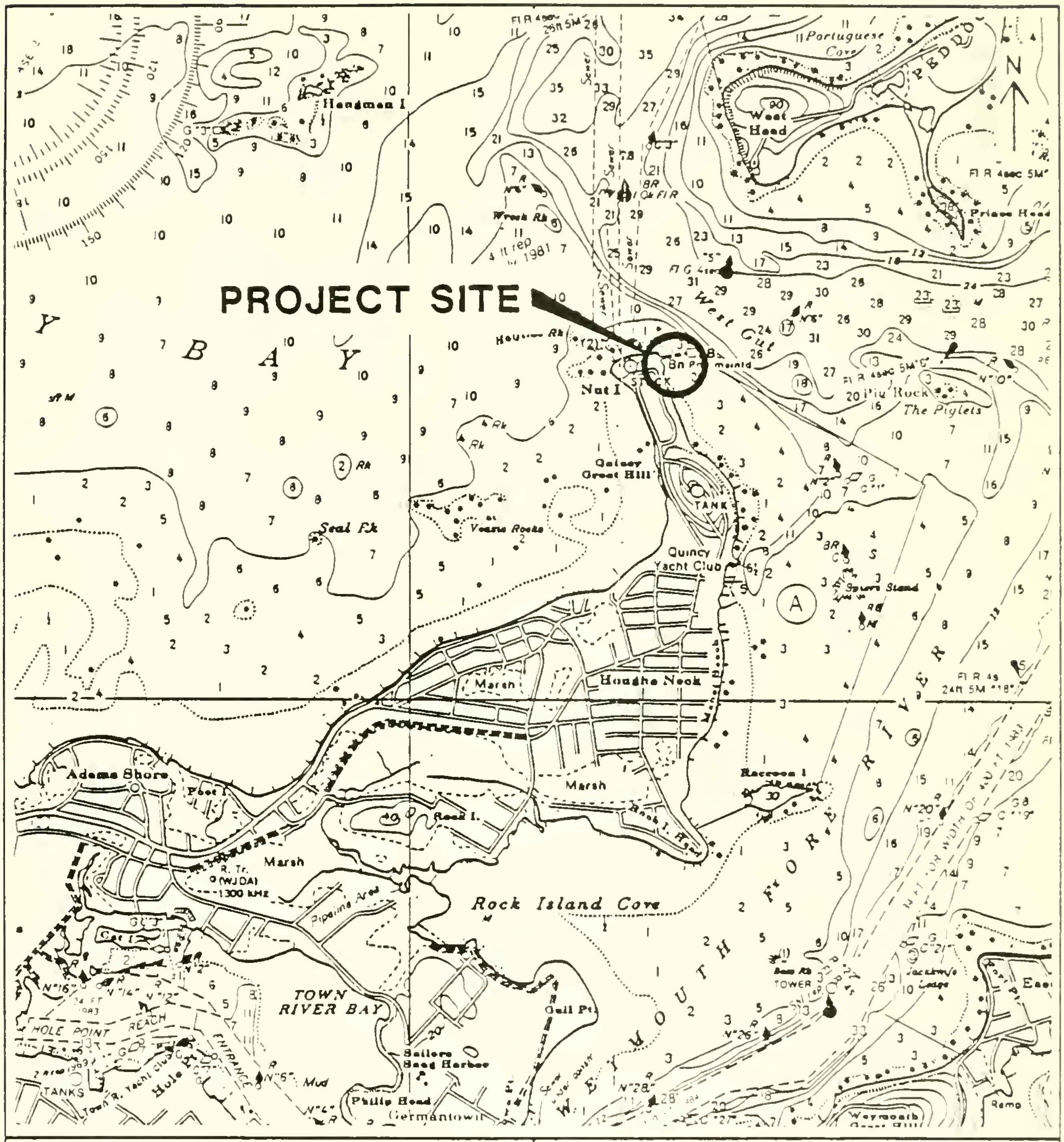

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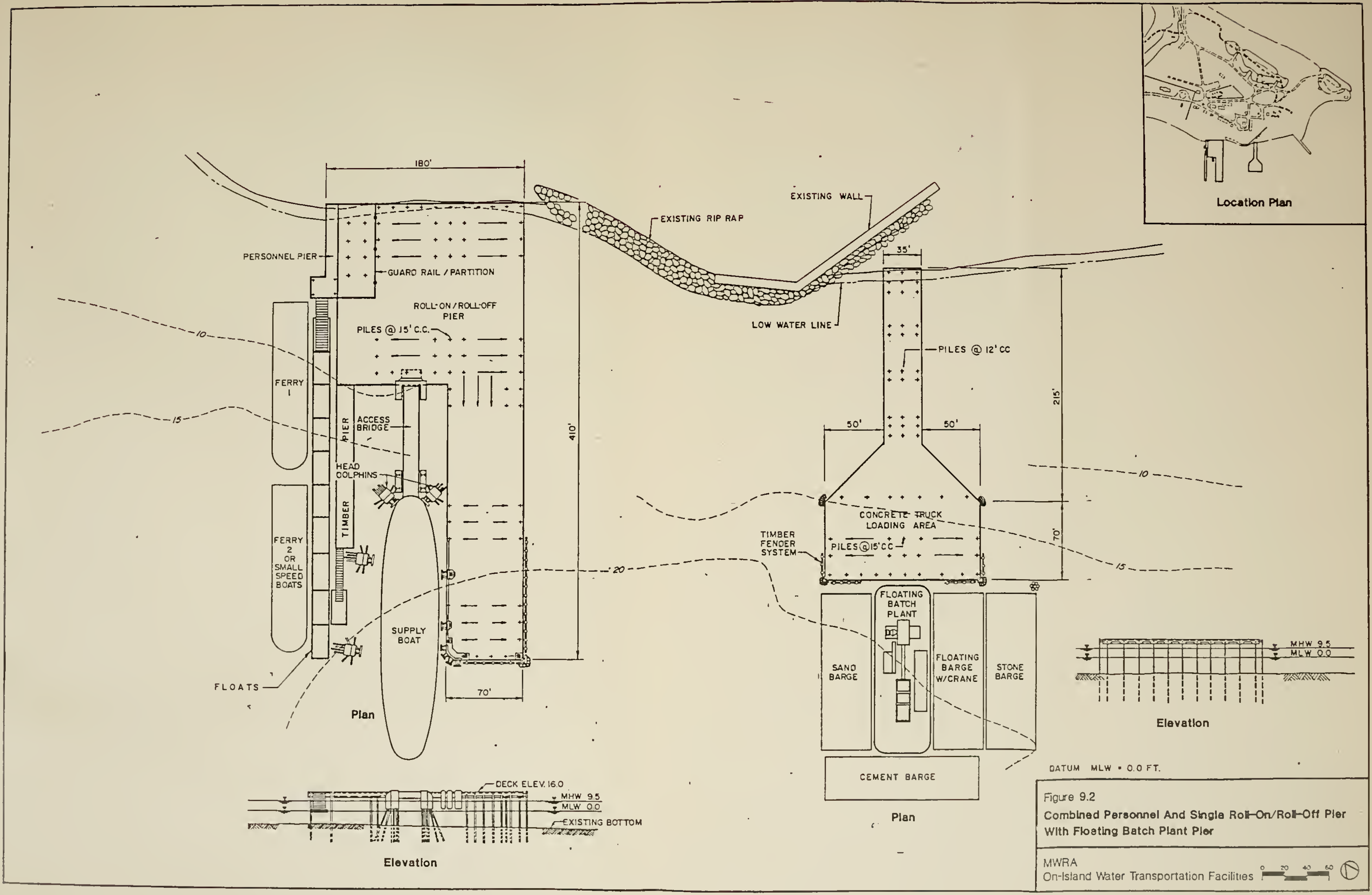

Figure 9.2

Combined Personnel And Single Roll-On/Roll-Off Pier With Floating Batch Plant Pier

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On-Island Water Transportation Facilities

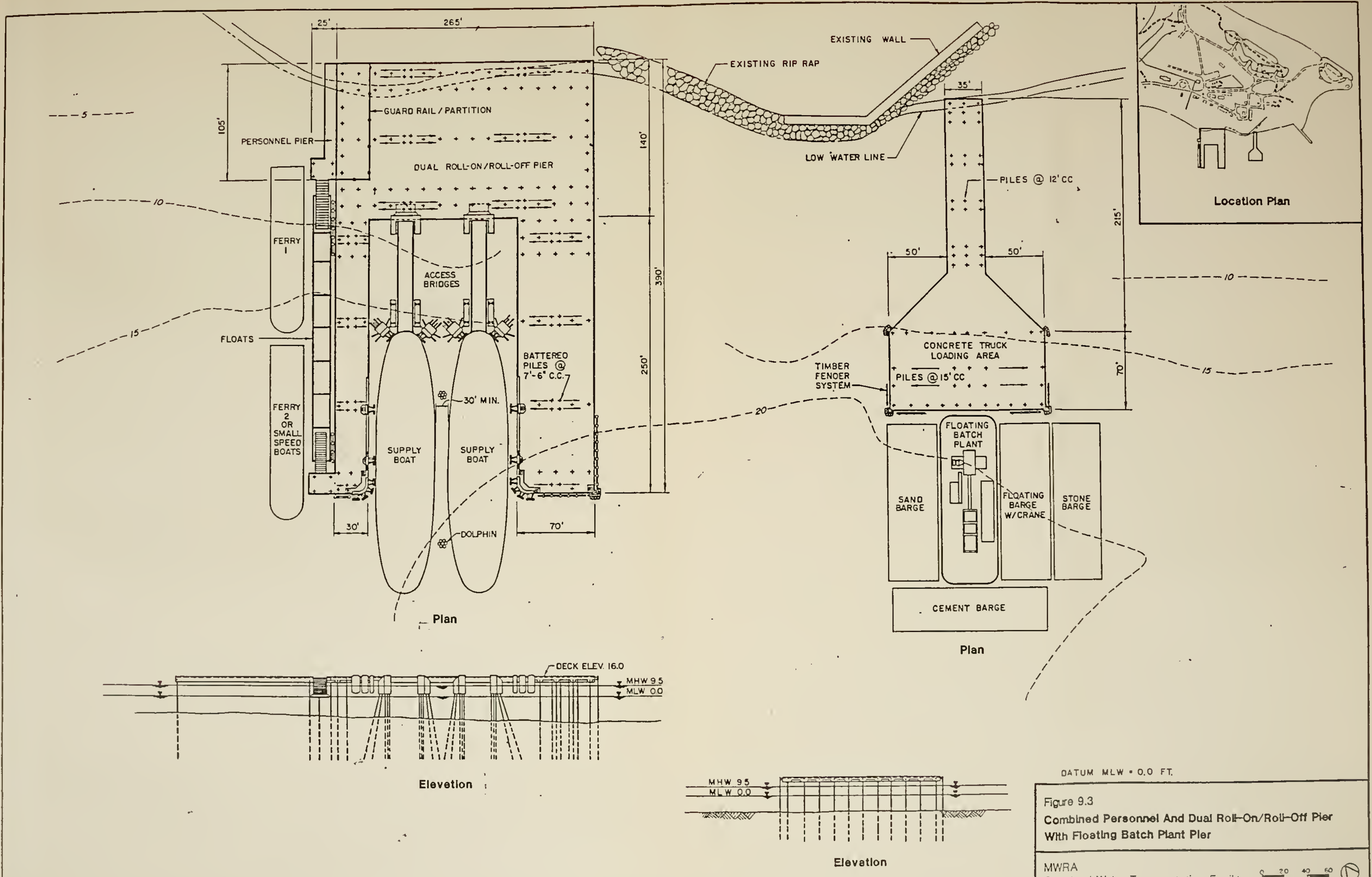

Figure 9.3

Combined Personnel And Dual Roll-On/Roll-Off Pier With Floating Batch Plant Pier

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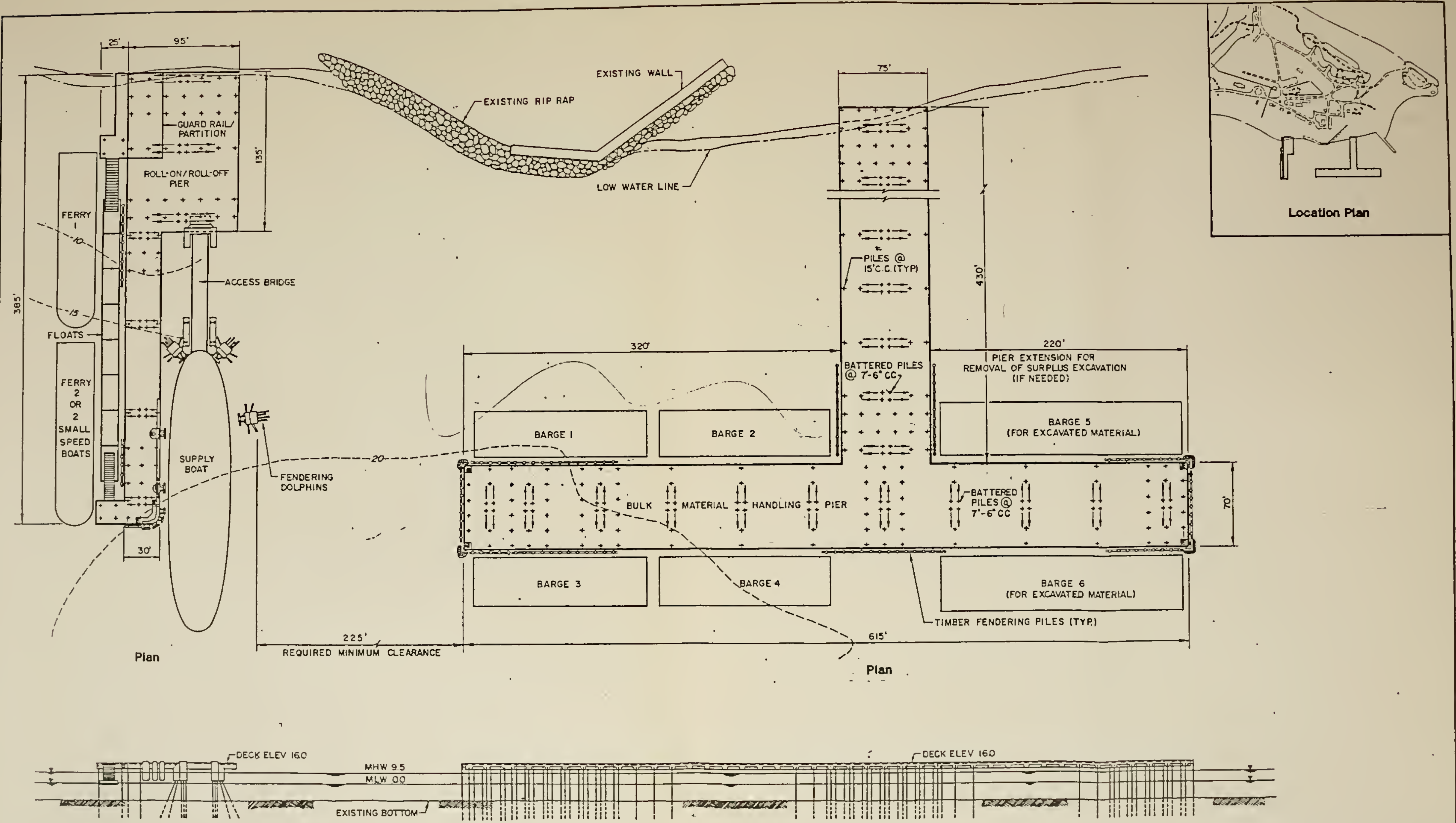

Figure 9.4
Bulk Pier And Combined Personnel/ Single Roll-On/Roll-Off Pier

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On-Island Water Transportation Facilities

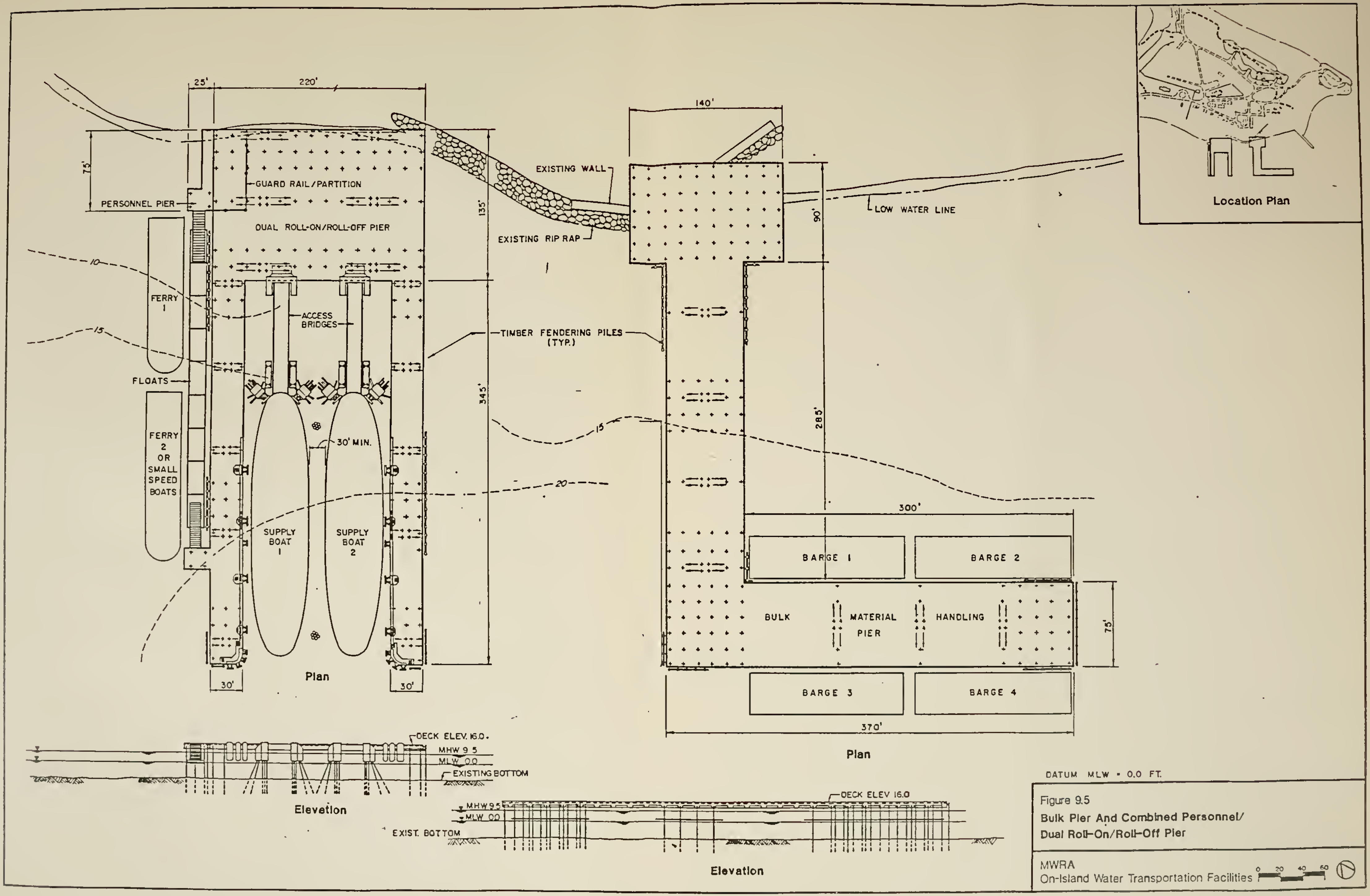

Figure 9.5
Bulk Pier And Combined Personnel/
Dual Roll-On/Roll-Off Pier

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On-Island Water Transportation Facilities

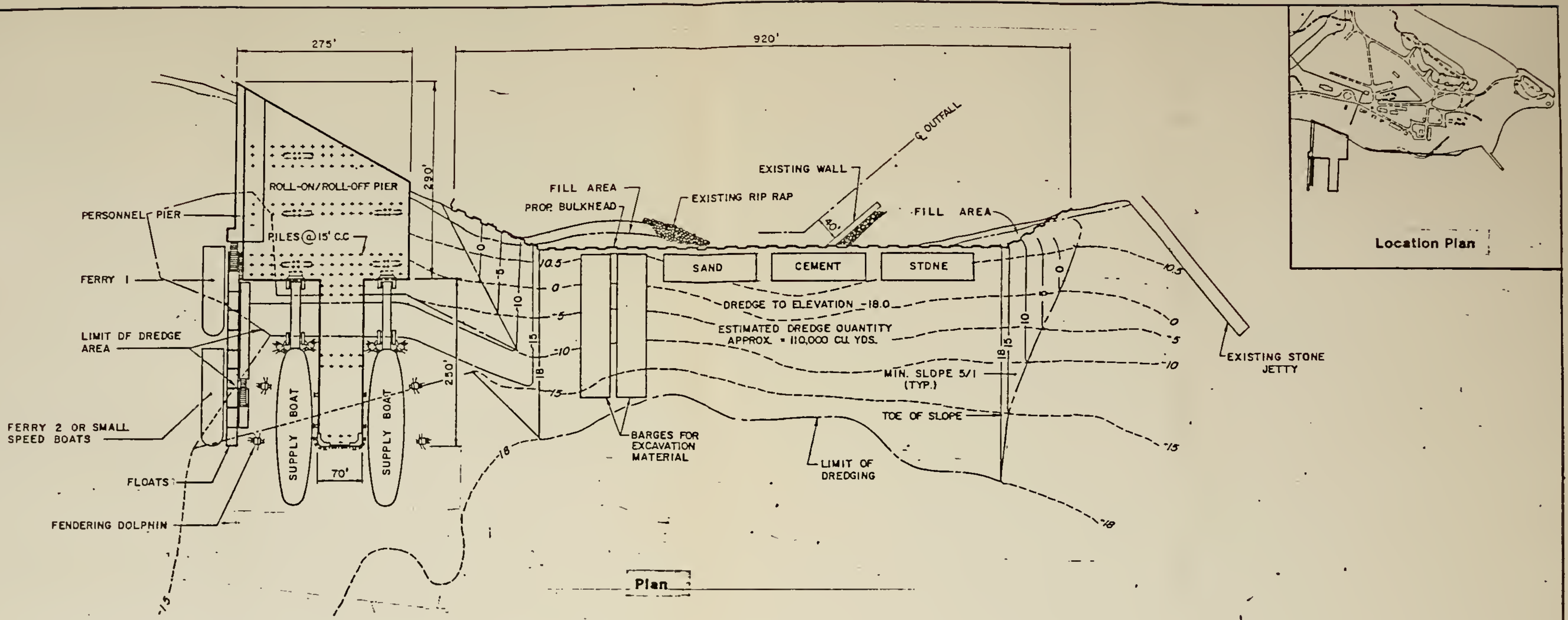

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Figure 9.8

One Combined Pier And Bulkhead With Dredging

MWRA

On-Island Water Transportation Facilities

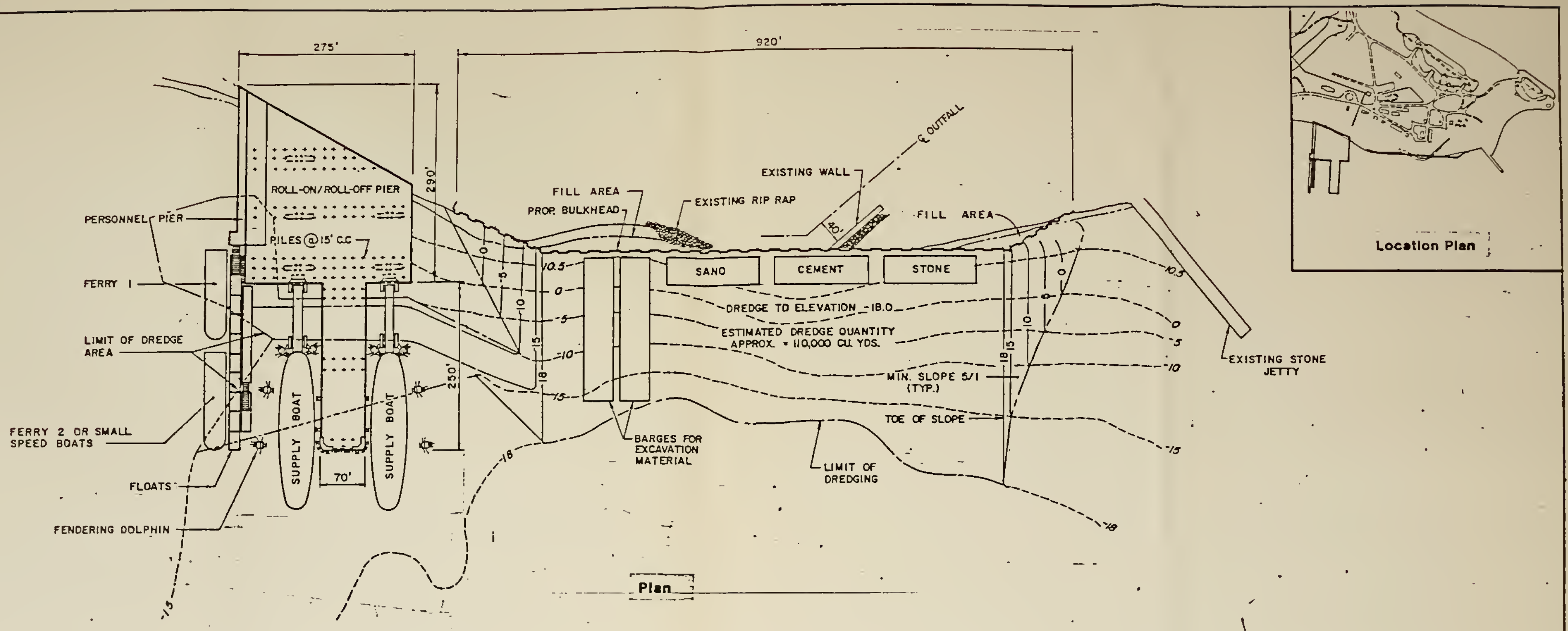

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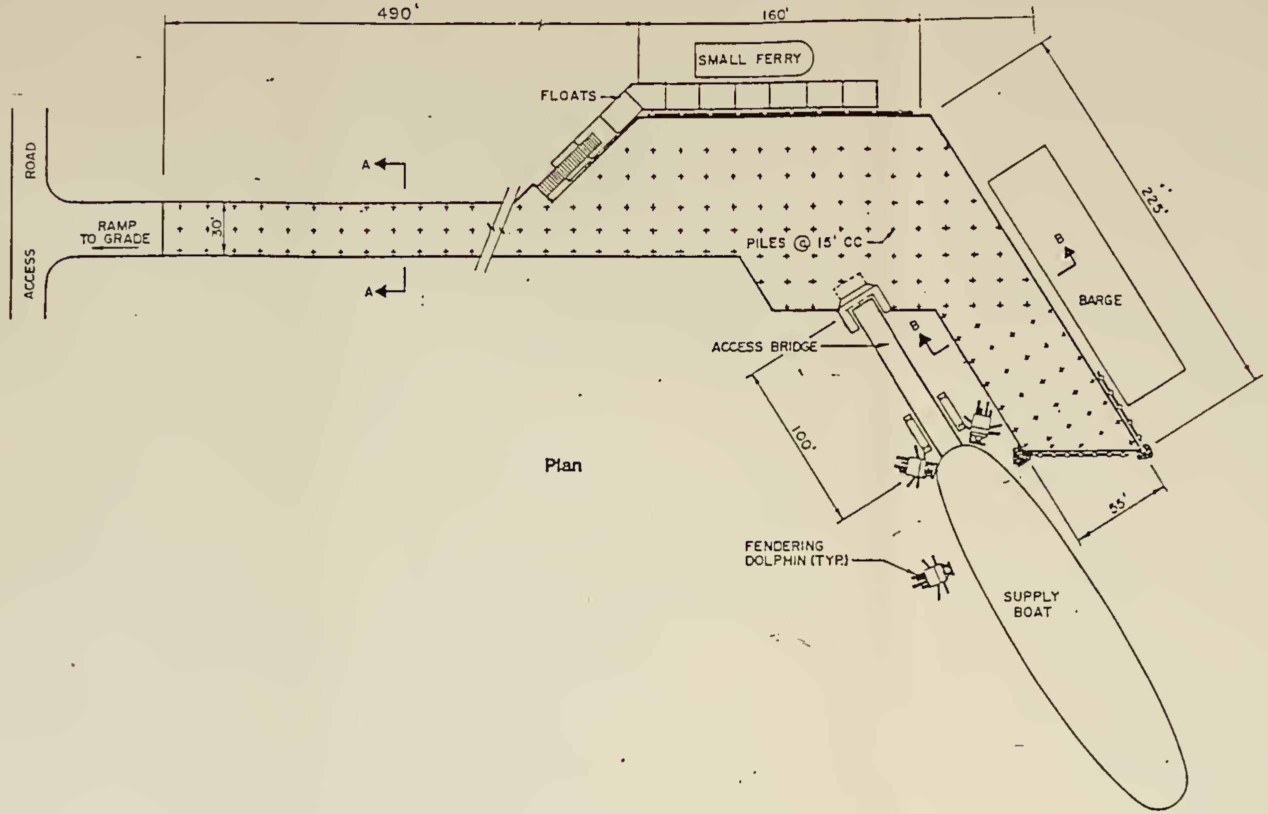
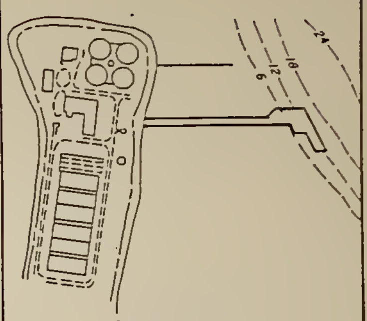
Figure 9.8
One Combined Pier And Bulkhead With Dredging

MWRA
On-Island Water Transportation Facilities

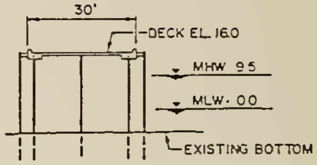
0 40 80 120



Plan



Location Plan



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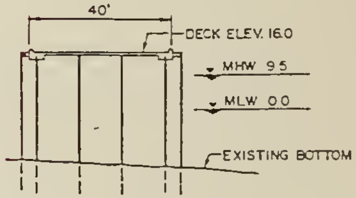

Section B-B

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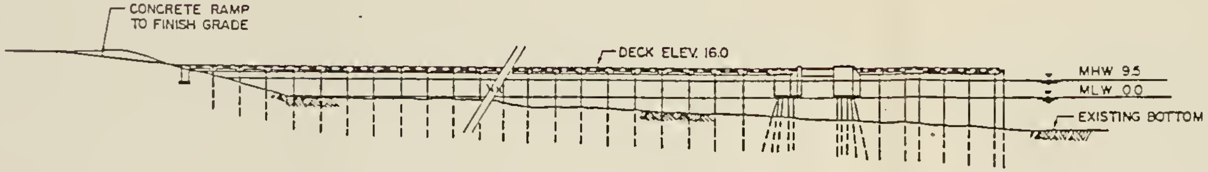


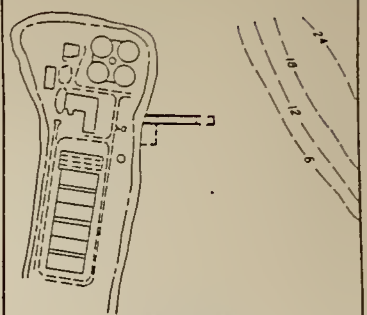
Elevation

DATUM MLW = 0.0 FT.

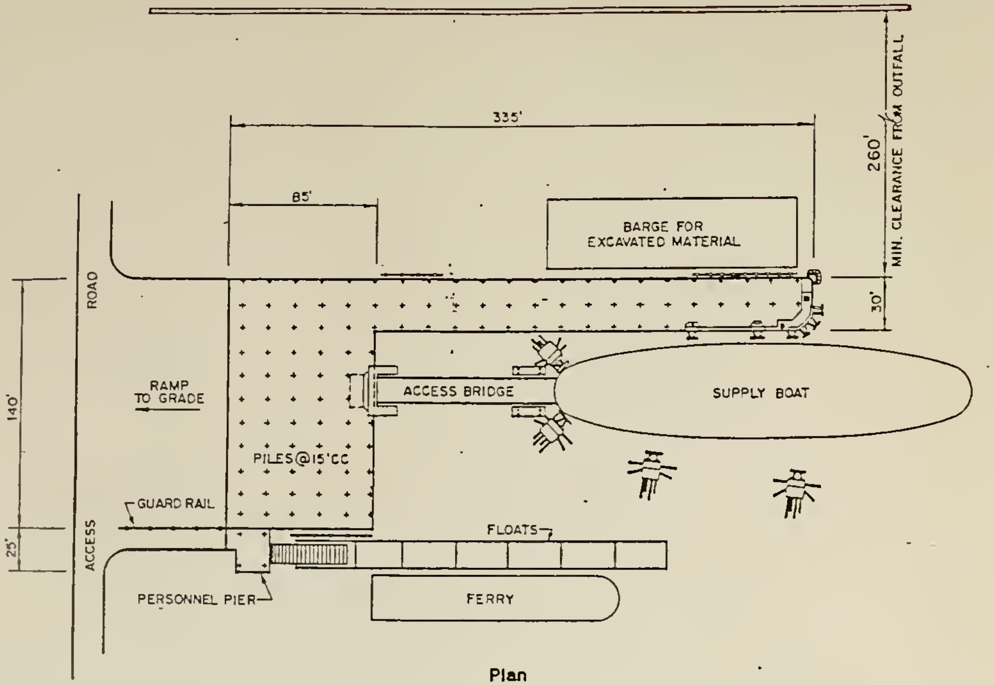
Figure 10.1

Nut Island - Extended Pier Option

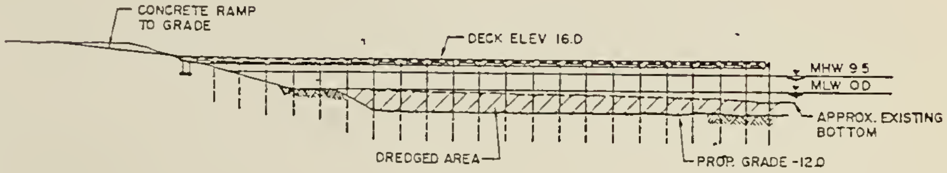
MWRA
On-Island Water Transportation Facilities



Location Plan



Plan



Elevation

DATUM MLW = 0.0 FT.

Figure 10.2
Nut Island
And Short Pier Option - East Side

MWRA
On-Island Water Transportation Facilities

0 20 40 60

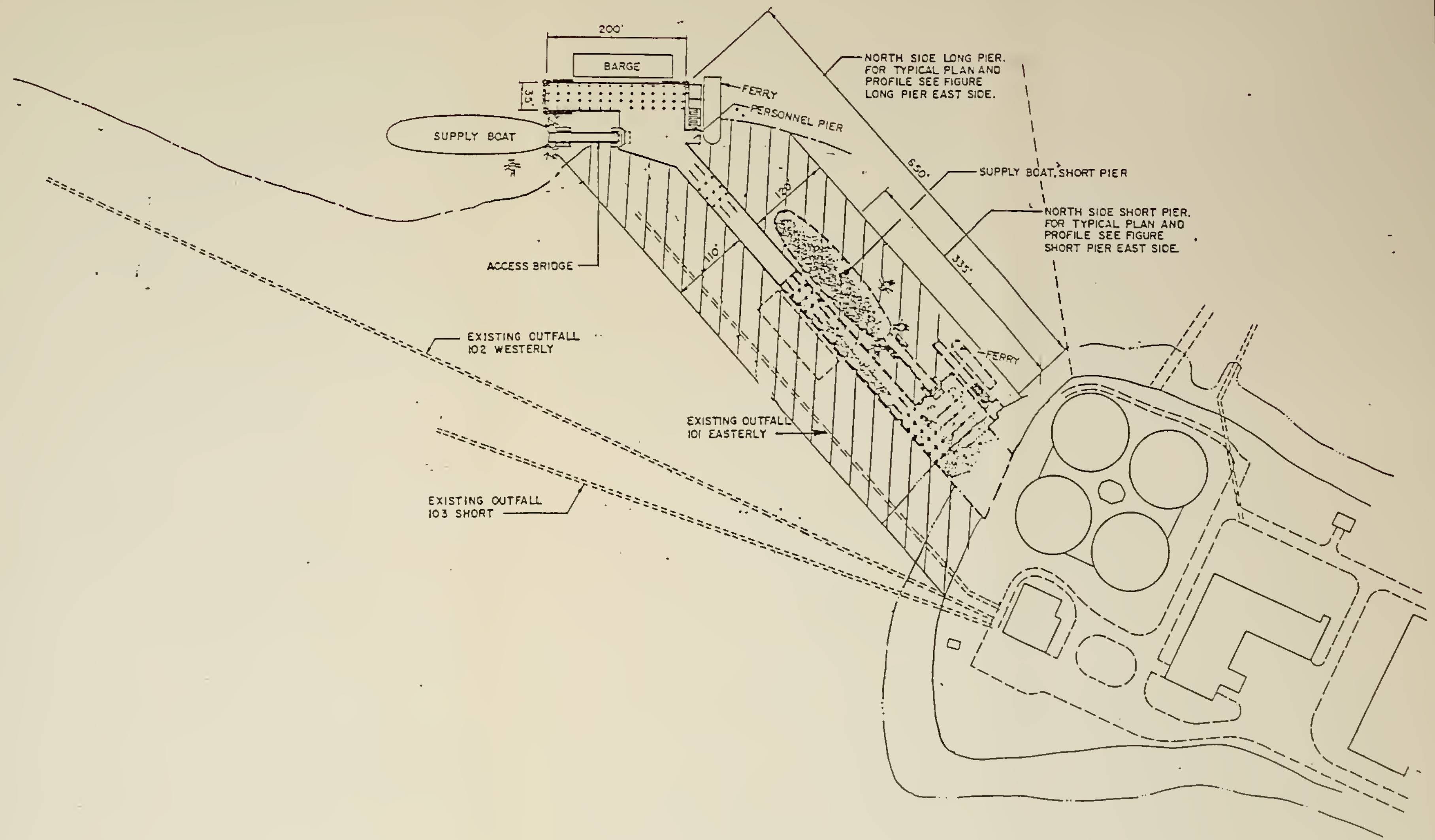


Figure 10.3

Nut Island – Long And Short Pier Options
North

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